

**ACPL ITEM
DISCARDED**

*
621
International
library of
technology

In84
31C
1353377

B &

PUBLIC LIBRARY
FORT WAYNE AND ALLEN COUNTY, IND.

STORAGE



**ACPL ITEM
DISCARDED**



MAY 18 66

B & I

International Library of Technology

31C

A SERIES OF TEXTBOOKS FOR PERSONS ENGAGED IN ENGINEER-
ING PROFESSIONS, TRADES, AND VOCATIONAL OCCUPATIONS
OR FOR THOSE WHO DESIRE INFORMATION CONCERN-
ING THEM. FULLY ILLUSTRATED

COMMON BRICKWORK
FACE AND ORNAMENTAL BRICKWORK
ARCHITECTURAL TERRA COTTA
HOLLOW TILE
BUILDING STONE
LATHING, PLASTERING, AND TILING
LIGHTING FIXTURES
ARCHITECTURAL DESIGN

SCRANTON
INTERNATIONAL TEXTBOOK COMPANY

1921

Common Brickwork: Copyright, 1920, by INTERNATIONAL TEXTBOOK COMPANY. Copyright in Great Britain.

Face and Ornamental Brickwork: Copyright, 1919, by INTERNATIONAL TEXTBOOK COMPANY. Copyright in Great Britain.

Architectural Terra Cotta: Copyright, 1920, by INTERNATIONAL TEXTBOOK COMPANY. Copyright in Great Britain.

Hollow Tile: Copyright, 1919, by INTERNATIONAL TEXTBOOK COMPANY. Copyright in Great Britain.

Building Stone: Copyright, 1898, by THE COLLIERY ENGINEER COMPANY. Copyright, 1907, by INTERNATIONAL TEXTBOOK COMPANY. Entered at Stationers' Hall, London.

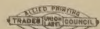
Lathing, Plastering, and Tiling: Copyright, 1898, 1899, by THE COLLIERY ENGINEER COMPANY. Entered at Stationers' Hall, London.

Lighting Fixtures: Copyright, 1907, by INTERNATIONAL TEXTBOOK COMPANY. Entered at Stationers' Hall, London.

Architectural Design: Copyright, 1902, by William R. Ware. Copyright, 1904, 1909, by INTERNATIONAL TEXTBOOK COMPANY. Entered at Stationers' Hall, London.

All rights reserved.

PRESS OF
INTERNATIONAL TEXTBOOK COMPANY
SCRANTON, PA.



PREFACE

The volumes of the International Library of Technology are made up of Instruction Papers, or Sections, comprising the various courses of instruction for students of the International Correspondence Schools. The original manuscripts are prepared by persons thoroughly qualified both technically and by experience to write with authority, and in many cases they are regularly employed elsewhere in practical work as experts. The manuscripts are then carefully edited to make them suitable for correspondence instruction. The Instruction Papers are written clearly and in the simplest language possible, so as to make them readily understood by all students. Necessary technical expressions are clearly explained when introduced.

The great majority of our students wish to prepare themselves for advancement in their vocations or to qualify for more congenial occupations. Usually they are employed and able to devote only a few hours a day to study. Therefore every effort must be made to give them practical and accurate information in clear and concise form and to make this information include all of the essentials but none of the non-essentials. To make the text clear, illustrations are used freely. These illustrations are especially made by our own Illustrating Department in order to adapt them fully to the requirements of the text.

1353377

In the table of contents that immediately follows are given the titles of the Sections included in this volume, and under each title are listed the main topics discussed. At the end of the volume will be found a complete index, so that any subject treated can be quickly found.

INTERNATIONAL TEXTBOOK COMPANY

CONTENTS

COMMON BRICKWORK	<i>Section</i>	<i>Page</i>
Brick	7	1
Manufacture of Brick.....	7	2
Classification of Brick.....	7	4
Size, Weight, and Quality of Bricks.....	7	7
Brickwork	7	8
Strength of Brickwork.....	7	9
Measurement of Brickwork.....	7	10
Bricklaying	7	12
Scaffolding	7	21
Brick Walls	7	25
Types of Brick Walls.....	7	25
Thickness of Walls.....	7	30
Bond in Brickwork.....	7	33
Openings in Walls.....	7	45
Brick Arches.....	7	47
Backing Up.....	7	53
Hangers, Anchors, etc.....	7	55
Chimneys and Fireplaces.....	7	60
FACE AND ORNAMENTAL BRICKWORK		
Definitions	11	4
Brief History of Brickwork.....	11	6
Face Brickwork.....	11	15
Description of Face Brick.....	11	15
Brick Shapes and Sizes.....	11	15
Brick Textures.....	11	19
Brick Colors.....	11	22
Molded Brick.....	11	24
Mortar and Mortar Joints.....	11	27

FACE AND ORNAMENTAL BRICKWORK

—Continued

	<i>Section</i>	<i>Page</i>
Bond	11	36
Pattern Work.....	11	40
Friezes and Bands.....	11	47
Borders and Panels.....	11	51
Fireplaces	11	60
Ornamental Brickwork.....	11	60

ARCHITECTURAL TERRA COTTA

Advantages, Uses, and Design.....	12	1
Plain Surfaces.....	12	6
Coloring Terra Cotta.....	12	14
Stock Designs.....	12	20
Strength and Weight of Terra Cotta.....	12	21
Architect's Drawings.....	12	21
Manufacturer's Drawings.....	12	24
Modeling	12	28
Molds	12	30
Manufacture of Terra Cotta.....	12	30
Finishes and Colors.....	12	32
Fitting and Numbering.....	12	35
Details of Construction.....	12	39
Shipping and Handling.....	12	67
Setting	12	68
Examples of Terra-Cotta Work.....	12	78

HOLLOW TILE

Advantages and Nature of Hollow Tile....	13	1
Shapes and Kinds of Hollow Tile.....	13	5
Regular, or Box-Shaped, Tile.....	13	5
T-Shaped Tile	13	15
H-Shaped Tile.....	13	20
Special Tile.....	13	23
Surfaces of Tile.....	13	28
Strength of Tile.....	13	29
Uses of Hollow Tile.....	13	30
Foundations of Hollow Tile.....	13	31
Exterior Walls of Hollow Tile.....	13	33

CONTENTS

vii

HOLLOW TILE—Continued	<i>Section</i>	<i>Page</i>
Veneered Walls of Hollow Tile.....	13	45
Openings in Walls.....	13	49
Columns and Piers.....	13	51
Attaching Furring to Walls.....	13	53
Hollow Tile Partitions.....	13	56
Floor Systems.....	13	57
Roof Construction.....	13	61
Stucco Finish.....	13	62
Examples of Buildings of Hollow Tile.....	13	67
BUILDING STONE		
Granites	37	1
Limestones	37	3
Sandstones	37	4
Qualities of Good Stone.....	37	5
Inspection and Tests.....	37	11
Stone Cutting and Finishing.....	37	12
Stone-Cutting Tools.....	37	12
Finish of Stonework.....	37	16
Carved Work.....	37	29
LATHING, PLASTERING, AND TILING		
Lathing	38	3
Wooden Laths.....	38	3
Metal Laths.....	38	6
Plaster Boards.....	38	10
Plain Plastering.....	38	11
Hard Wall Plasters.....	38	25
Ornamental Plastering.....	38	28
Plaster Ornaments and Scagliola.....	38	31
Stucco	38	32
Whitewashing	38	35
Tiling	38	38
LIGHTING FIXTURES		
History of Illumination.....	42	1
Illuminating Appliances.....	42	3
Gas and Electric Fixtures.....	42	3
Construction of Lighting Fixtures.....	42	59

ARCHITECTURAL DESIGN	<i>Section</i>	<i>Page</i>
Elements of Design.....	52	3
Elements of Composition.....	52	10
Composition in Architecture.....	52	13
Methods of Proportioning Masses.....	52	32
Grouping of Principal Details.....	52	39
Grouping of Minor Details.....	52	43
Classic Proportions.....	52	46
The Orders.....	52	46
The Greek Orders.....	52	96
Pilasters	52	103
Pedestals	52	104
Pediments	52	110
Intercolumniation	52	113
Superposition	52	116
Application of Principles.....	52	123
Problems in Design.....	52	133
Wash Drawings.....	52	143
Practical Planning.....	52	146

COMMON BRICKWORK

BRICK

1. Definition and Description.—Bricks may be defined as solid building units made of burned clay. They are comparatively small in size, therefore easily handled, and being already burned are extensively used in buildings that are intended to be fire-resistive and in other forms of construction that are permanent in character. When referred to in the mass, or as a building material, they are called *brick*.

Brick can be made cheaply and, when hard burned and laid in good mortar, is one of the most durable building materials in use. Common brick can be used to form solid, or even hollow, walls when desired, or can be used to back up a wall that is faced with a most costly material, such as face brick, terra cotta or stone. While common bricks are manufactured mainly with a view to service, they may be used for facing walls. In many localities the clays or shales used in making common brick produce, when burned, a variety of colors and textures resulting in the most pleasing effects as laid in the wall. These effects may be obtained by using the bricks as they come from the kiln without selecting, or by selecting and grading the bricks. The possibilities of artistic treatment of wall surfaces are not even limited by the range of color or texture. With the use of any good hard brick a variation in color effect and texture of wall surface may be obtained by varying the character of the bond and the size and color of the mortar joint. This use of certain kinds of common brick is also discussed and illustrated in the Section on *Face and Ornamental Brickwork*.

MANUFACTURE OF BRICK

2. Ingredients.—The principal material used in making brick is clay, where naturally suitable as it comes from the clay bank, or a combination of clay and sand, called silicate of alumina. Suitable basic materials of this nature are found throughout almost every state in this country. Brickyards abound in nearly every locality and in the making of brick and other clay products a practically inexhaustible material is drawn upon. This material, as found in nature, generally contains small quantities of other chemical substances such as iron, magnesia, lime, potash, etc. Each of these substances has a particular effect upon the color, hardness, and durability of the brick, and by the judicious use of these substances, either alone or in combination, certain characteristics in the finished brick can be obtained. Such combinations are often made by mixing together two or more clays containing different chemical substances.

HAND-MADE BRICKS

3. In the process of making clay bricks by hand, the clay is mixed with water and worked to a plastic state in a *pug mill*, and then the soft plastic clay is pressed into molds by hand. The molds are sometimes dipped into water, just before being filled with the clay, to prevent the mud from sticking to them when the mold is removed. Bricks molded in these wet forms are known as *slop bricks* and also as *water-struck bricks*. Sand is sometimes sprinkled into the molds to prevent the clay sticking, or to produce a sand-finished texture on the faces as laid, and the bricks from sanded molds are called *sanded bricks*. After the bricks are shaped in the mold, they are removed and laid in the sun, or in a drying house, for 3 or 4 days, after which they are stacked in kilns and burned.

The hand method of making bricks and the sun method of drying, being very slow and laborious, have been almost entirely displaced by more economical and expeditious ones in which the work is done by machinery.

MACHINE-MADE BRICKS

4. Nearly all bricks are now made by machinery. Where they are made on a large scale, steam shovels frequently are used for excavating the clay, and conveyors carry the raw clay to the mill and also convey the molded bricks to the drying sheds and the kilns.

Machine-made bricks are usually formed by one of three methods known as the soft-mud, the stiff-mud, and the dry-clay process.

5. Soft-Mud Process.—In the **soft-mud process**, the clay is soaked in water until soft. It is then thoroughly mixed by machinery, and pressed into molds by a plunger. The bricks are then dried and burned.

6. Stiff-Mud Process.—In the **stiff-mud process**, the clay is first thoroughly ground, and just enough water is added to make a stiff mud. After this mud is mixed in a pug mill, it is placed in a machine having a die the exact size of the brick required. The opening in this die is made the size of either the end or the side of a brick. The machine forces a continuous bar of clay through this die, and as it emerges it is automatically cut into bricks, which are then taken to the drying yard. The bricks that are cut on the ends are called *end cut*. Those cut on the sides are known as *side cut*. The soft bricks are placed in rows in a yard covered by a rough shed, with open sides, where they are sun or air dried for a considerable length of time or are run on special trucks into drying houses and are dried in from 4 to 8 days by steam or waste heat from the kilns. When properly dried they are placed in the kiln and burned.

7. Dry-Clay Process.—The process often employed in the best work is the **dry-clay process**. In this method of manufacturing brick, the clay is used just as it comes from the bank, and is apparently perfectly dry. It contains, however, about from 7 to 10 per cent. of moisture. The clay is filled loosely into molds of the same width and length as a brick, but deeper than the required thickness of the brick. A plunger

that exactly fits the mold is then forced in under heavy pressure and compresses the clay to the size of the brick desired. The bricks are then removed to the kiln and fired.

Molded bricks are made in the same way, the difference being that the mold is made to give the shape of the brick required.

Whenever the term *pressed brick* is used, it should mean brick made by the dry process. There are many so-called *dressed* or *face bricks*, however, that are made by recompressing soft-mud bricks.

DRYING AND BURNING OF BRICK

8. Bricks must be dried before being burned. Soft-mud bricks naturally require a longer time to dry than stiff-mud bricks. Having been properly dried, they are placed in kilns and burned. The types of kilns used are the up-draft, the down-draft, and the continuous kilns. The details of these kilns and their operation will not be described here. The important thing is that the bricks shall be well burned and satisfactory in shape and color. It might be said, however, that bricks burned in the modern forms of kilns are more uniform in color, shape, and hardness than those made in the old-fashioned kiln.

CLASSIFICATION OF BRICK

9. **Common Brick.**—The term *common brick* includes all brick made for structural purposes and produced without artificial scoring or marking of the exposed surface to give especial texture.

The distinguishing line between common and face brick in modern practice seems to be the special mixing of ingredients and the artificial coloring and scoring or rough texture, or the repressing process of the smooth brick, and the fact that face brick are graded, handled, and packed with great care.

Many face-brick plants and nearly all paving plants produce a proportion of common brick. Face brick *culls* are sold as *commons*.

The terms applied to grades of common brick vary in different parts of the country. In some places the bricks, although not alike, are sold without selection or grading. In other places the kiln is graded as *front* brick and *back* brick, the front being hardest burned. In others there are *hard* and *kiln run* brick.

In the overburned brick called *clinkers*, the clay fuses and causes irregular shapes and sizes. These bricks are usually extremely hard and very durable. Clinker bricks are in favor with many architects for ornamental purposes and should be laid with proper bond, size and kind of joint and color of the mortar.

Common bricks burned in the old-style up-draft kilns are classified according to their position in the kiln, which affects the amount of heat to which they are subjected. In some localities three grades of brick are produced in these kilns, namely, *arch* or *clinker* brick; *red*, or *well-burned*, brick; and *soft*, or *salmon*, brick. In other localities four grades are produced, namely: *rough-hard* (corresponding to arch brick), *straight-hard*, *stretcher*, and *salmon*.

Arch, or clinker, brick is the name applied to the bricks that have been nearest the fire and are consequently overburned.

Red, well-burned, or straight-hard, brick constitutes the hardest and the largest part of the product of the kiln; *stretcher* brick being a selection of the most uniform of these.

Salmon brick is the name applied to those that have been farthest from the fire and are consequently underburned and soft. In many localities these are used for interior, or unexposed walls, party walls and others not carrying heavy loads.

In certain localities the clay is of such a composition that the best brick from the kiln is of a salmon color and such brick should not be confused with the salmon brick just described.

The American Society for Testing Materials has adopted names for common brick as follows: *vitified brick*, *hard brick*, *medium brick*, and *soft brick*. These grades conform in general to the classification just mentioned.

10. Face Brick.—Face bricks are made of specially selected materials so that the brick shall be of certain desired

colors, and with the faces scored or of a rough texture. These bricks are described in the Section *Face and Ornamental Brickwork*. Common bricks are often made or selected for color, *fire-flashed* effects and shape, and used for facing brick walls.

11. Pressed Brick.—Pressed bricks are those that have been pressed in a machine, and are usually hard, smooth, and have sharp corners and true shapes. They are used as face brick.

12. Firebrick.—Firebricks are made from fireclay and are used for lining furnaces, lime kilns, fireplaces, and chimneys in factories. They are usually somewhat larger than ordinary building bricks, and should be of homogeneous composition and texture, uniform in size, of a regular shape, easily cut, and not fusible. The best firebricks are hand-molded.

13. Paving Brick.—Paving bricks are usually made by the stiff-mud process, being repressed to give them a better shape, and are composed of about three parts of shale clay to one part of fireclay. They are burned at a high temperature to the point of vitrification, that is, to a heat at which they begin to fuse or melt. These bricks have a high crushing strength and absorb very little moisture. They are used principally for paving driveways, and occasionally for paving flat roofs on fireproof buildings.

14. Hollow Brick.—Hollow bricks are made of a stiff-mud mixture by machinery, as holes must be formed in the body of the brick. Hollow bricks are now being made more generally by manufacturers of terra-cotta tile, as the material and machinery used in manufacturing tile is better adapted to making hollow brick than is the machinery used in brick making.

15. Sand, or Sand-Lime, Brick.—The composition of **sand brick** is usually 95 per cent. of sand and 5 per cent. of slaked lime. This mixture is forced into molds under a very high pressure, and the bricks are removed from the molds and heated with superheated steam. These bricks can be made in

many colors by artificial means, and can thus be used to effect the most pronounced designs. Sand bricks are manufactured by many firms in the United States, some of which make a very good dense brick, while others make an inferior sandy article.

SIZE, WEIGHT, AND QUALITY OF BRICKS

16. Size and Weight.—There is no universally accepted standard size of brick in America, although the American Society for Testing Materials and the Common Brick Manufacturers Association of America have adopted as a standard size for common brick, 8 in. $\times$ 3 $\frac{3}{4}$ in. $\times$ 2 $\frac{1}{4}$ in. The dimensions of brick vary with the locality and also with the maker. Bricks taken from the same kiln will vary in size due to the amount of heat to which they have been subjected.

In the New England States, the average size of a common brick is about 7 $\frac{3}{4}$ in. $\times$ 3 $\frac{3}{4}$ in. $\times$ 2 $\frac{1}{4}$ in.; New York and New Jersey bricks will run about 8 in. $\times$ 4 in. $\times$ 2 $\frac{1}{2}$ in.; and the walls laid in them will measure about 8, 12, 16, and 20 inches in thickness for 1, 1 $\frac{1}{2}$, 2, and 2 $\frac{1}{2}$ bricks. Some of the western common bricks measure 8 $\frac{1}{2}$ in. $\times$ 4 $\frac{1}{8}$ in. $\times$ 2 $\frac{1}{2}$ in., and the thickness of the walls measures about 9, 13, 18, and 22 inches for thicknesses of 1, 1 $\frac{1}{2}$, 2, and 2 $\frac{1}{2}$ bricks. On the seacoast of some of the Southern States, the bricks will average 9 in. $\times$ 4 $\frac{1}{2}$ in. $\times$ 3 in.

The weight of bricks varies considerably with the material used in their manufacture and also with their size. Common bricks will average about 4 $\frac{1}{2}$ pounds each.

17. Quality.—All bricks should be of uniform dimensions, free from twists, cracks, and pebbles, and should have sharp corners. The bricks should be well burned but not vitrified lest they become brittle. When two bricks are struck together, they should emit a metallic ring. A good brick will not absorb over 10 per cent. of its weight of water if allowed to soak for 24 hours.

COLOR OF BRICK

18. The color of brick is usually not considered of any importance in common brickwork, but as walls of this kind of brick are sometimes exposed to view, the selection of bricks as to color and shade may be desired and consequently the architect's specifications should clearly state if this selection is required.

The color of common bricks depends largely upon the kind of clay used in making them and the temperature attained in the kiln during the burning.

Bricks burned in down-draft kilns are more uniformly burned and are consequently of a more uniform red color.

BRICKWORK

GENERAL DISCUSSION

19. Definition.—By the term *brickwork* is meant any construction made of bricks laid up in mortar. It can readily be seen that the strength of brickwork is not dependent on the strength of the brick alone. Other factors influence this, such as the strength of the mortar and the method of laying up and bonding the brick. Therefore, the value of brickwork, so far as strength and stability is concerned, may be decreased by the use of inferior mortar or by being laid by a bricklayer who does not understand his trade.

20. Importance of Mortar.—In laying bricks, it is customary to bed them in mortar. The mortar serves several purposes. It tends to make the wall waterproof and air-proof under ordinary conditions; it forms a cushion to take up the irregularities in the bricks and thus distributes the pressure evenly, and it bonds the whole wall into one solid mass, which increases its strength and stability.

Mortar for brickwork may be made of various combinations. It may be formed either of slaked or hydrated lime and sand in

proper proportions, or of lime and sand mixed with a small quantity of cement. It may also be made of cement and sand, or cement and sand to which a small percentage of slaked or hydrated lime is added. Lime mortar is, however, to be avoided in work coming in contact with earth or subject to dampness. Mortars of various kinds and qualities are more fully discussed in the Section *Limes, Cements, and Mortars*.

21. Size of Mortar Joints.—With soft-mud or stiff-mud bricks there are likely to be some irregularities which make necessary larger mortar joints than are generally required for pressed brick. For this reason common bricks are generally laid in mortar about $\frac{1}{4}$ inch to $\frac{1}{2}$ inch in thickness.

If a wall is faced with common bricks or bricks that have a rough texture, the joints in the facing are sometimes made as much as $\frac{3}{4}$ inch in thickness and the backing is adjusted either by additional courses of bricks or thicker mortar joints than usual to bring the two kinds of brickwork to the same level, so that they can be bonded together at approximately every six or eight courses in the height of the wall.

STRENGTH OF BRICKWORK

22. Bricks for ordinary requirements are seldom tested for crushing strength, as the masonry formed of well-burned brick laid in good cement mortar will carry all ordinary loads. Bricks should not fail, however, under a crushing load of less than 1,800 pounds per square inch.

The strength of brickwork is influenced by the quality of the brick and the mortar of which it is composed. In cases where the brick is harder than the mortar, the latter is the factor that determines the strength of the brickwork. For this reason the load that may be placed upon brickwork varies with the kind of mortar that is used in its construction. These allowable loads are stated in the building laws in various localities. Local building laws should therefore be consulted when determining the loads on walls of buildings that come under the jurisdiction of such laws. Where no such laws exist, the Building Code

recommended by the National Board of Fire Underwriters is authority for the statement than 111 pounds per square inch may be taken as a safe load for masonry formed of bricks laid in good lime mortar; 208 pounds per square inch for lime and Portland cement mortar; 208 pounds for natural cement mortar and 250 pounds for Portland cement mortar in the proportion of three parts of sand to one part of cement, of which not more than 15 per cent. of the Portland cement by volume may be replaced by an equal amount of dry hydrated lime.

MEASUREMENT OF BRICKWORK

23. The usual method of measuring brickwork is by the thousand bricks laid in the wall. A customary method of estimating the number of bricks in a piece of brickwork is first to determine the entire area of the face of the wall in square feet, measurements being taken on the outside of the wall, and not on the inside. This is done to offset the extra labor that is required in laying up the corners or angles. The number of bricks is computed approximately from these areas, using the number of bricks to the square foot as shown in Table I. Thus, when using a brick $8'' \times 3\frac{3}{4}'' \times 2\frac{1}{4}''$, laid with a $\frac{1}{2}$ -inch joint, there would be 6.17, or $6\frac{1}{6}$, bricks per square foot for a wall 4 or $4\frac{1}{2}$ inches, or 1 brick, thick; $12\frac{1}{3}$ bricks for a wall 8 or 9 inches, or 2 bricks, thick; $18\frac{1}{2}$ bricks for a wall 12 or 13 inches, or 3 bricks, thick; $24\frac{2}{3}$ bricks for a wall 16 or 17 inches, or 4 bricks, thick, and so on, $6\frac{1}{6}$ bricks per square foot being added for every additional brick in the thickness of the wall. The estimate is then based on the number of thousands of brick, at a suitable price per thousand, including labor and mortar. For example, a wall 24 feet long, 12 feet high and 20 inches, or 5 bricks, thick, would contain $24 \times 12 = 288$ square feet 5 bricks thick. At $6\frac{1}{6}$ bricks this would be $288 \times 5 \times 6\frac{1}{6} = 8,880$ brick.

24. The window and door openings in brick walls should always be deducted. While formerly it was in some places the custom not to deduct openings in estimating brickwork, modern

methods adopted by all careful and efficient contractors include the figuring out with exactness the number of bricks required, as above indicated. This applies with force to the quantity of mortar necessitated for the brick. If walls are built hollow a deduction is likewise made for absence of brick and mortar therein. The same is true of all flues in chimneys, the saving in brick alone paying for the cost of the flue lining which

TABLE I
NUMBER OF BRICKS TO THE SURFACE FOOT FOR
DIFFERENT SIZES OF BRICKS WITH JOINTS
OF VARIOUS THICKNESSES

Size of Brick Inches	Thickness of Joint					
	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$
	Number of Bricks					
$7\frac{1}{2} \times 3\frac{3}{8} \times 2\frac{3}{8}$	7.31	7.08	6.86	6.65	6.45	6.26
$7\frac{3}{4} \times 3\frac{3}{4} \times 2\frac{1}{4}$	7.44	7.20	6.97	6.75	6.55	6.35
$8 \times 3\frac{3}{4} \times 2\frac{1}{4}$ *	7.22	6.98	6.76	6.55	6.35	6.17
$8 \times 4 \times 2\frac{1}{2}$	6.55	6.35	6.16	5.98	5.81	5.65
$8\frac{1}{4} \times 3\frac{3}{4} \times 2\frac{1}{4}$	7.00	6.78	6.56	6.36	6.17	5.98
$8\frac{1}{4} \times 4 \times 2\frac{1}{4}$	7.00	6.78	6.56	6.36	6.17	5.98
$8\frac{1}{2} \times 4\frac{1}{8} \times 2\frac{3}{8}$	6.47	6.27	6.08	5.90	5.73	5.57
$8\frac{1}{2} \times 4\frac{1}{8} \times 2\frac{1}{2}$	6.17	5.99	5.81	5.64	5.49	5.33
$9 \times 4\frac{1}{2} \times 3$	4.92	4.79	4.67	4.55	4.45	4.33

*Standard size adopted by American Society for Testing Materials and The Common Brick Manufacturers' Association of America.

should invariably be used, except in the case of thick walls as mentioned in the articles on *Chimneys and Fireplaces*.

25. In Table I is given the number of bricks required for 1 square foot of face of a wall one brick thick—that is, having a thickness equal to the width of a brick—when laid with mortar joints of different thicknesses and bricks of various sizes.

26. This table will be found useful in estimating the number of bricks in any wall. To find the number of bricks per

square foot of face of a wall of any thickness, find in the table the number of bricks per square foot of face of wall for the size of brick and thickness of joint that are to be used and multiply this number by the number of bricks in thickness of the wall. The result will be the number of bricks per square foot of face of the wall in question.

27. For example, according to the table, if bricks $8\frac{1}{4}$ in. $\times 4$ in. $\times 2\frac{1}{4}$ in. in size are to be used, with mortar joints $\frac{3}{8}$ inch in thickness, the number of bricks per square foot of the face of the wall will be 6.36, if the wall is one brick in thickness; if the wall is two bricks in thickness, it will contain 12.72 bricks; if three bricks thick, 19.08 bricks; if four bricks thick, 25.44 bricks.

It will be observed in Table I that the two $8\frac{1}{4}$ -inch bricks show the same number of bricks per surface foot. The reason for this is that the $8\frac{1}{4}$ - and $2\frac{1}{4}$ -inch dimensions are the only ones that show on the face of the wall. The $3\frac{3}{4}$ - and 4-inch dimensions affect only the thickness of the wall.

28. Labor Required.—The amount of labor required for laying brick is a very uncertain quantity. An average man may lay from 750 to 1,000 bricks per day where the work is somewhat broken up and there are openings, or where the walls are thin. On thick straight walls with few openings a man may lay 1,200 to 1,500 bricks per day.

BRICKLAYING

TOOLS AND METHODS

29. Tools Used in Bricklaying.—The tools that are required in building brickwork are a two-foot rule, a long and a short plumb-rule, a level, a large steel trowel, a small steel trowel, a cutting-out hammer, a bricklayer's set, a brick jointer, wooden gauges for measuring bricks, a mason's linen line, chalk, a pencil, and leather protectors for the hand when laying wet or rough-cut bricks.

30. The **long plumb-rule**, or **plumb**, should be from 3 feet 6 inches to 4 feet long, about $3\frac{3}{4}$ inches wide, and about



FIG. 1

$1\frac{1}{8}$ inches thick, with two plumb-glasses at opposite ends, like those shown at *b* in Fig. 1.

The **short plumb-rule**, or **plumb**, should be from 16 in. to 18 in. long, with one plumb-glass like that shown at *b* in Fig. 1 and one level glass, as at *a* in Fig. 1.

31. In Fig. 1 is shown what is known as a combination plumb-rule and level. It is used in a horizontal position as a level and the level glass *a* indicates when the level is exactly horizontal. It is used as a plumb-rule by holding one edge against the work to be plumb and observing the level glasses *b*. A plumb-bob may be suspended from either end of the instrument so that it will hang in one of the openings *d*. The work is then tested by holding one edge of the plumb-rule against it and moving the instrument until the plumb-line coincides with the center line on the face of the plumb; then if the work does not coincide with the edge of the rule it is out of plumb or not perpendicular.

32. A simple form of **plumb-rule**, shown in Fig. 2, is made of a piece of board *a* $\frac{7}{8}$ inch thick and 3 or 4 inches in width. The edges of the board and the line *d* are parallel. A plumb-bob *b* is suspended on a cord fastened through the notches at the top of the rule and hangs in the opening *c*. When the edge of the rule is placed against a vertical surface and the line coincides with the middle line *d* on the rule the surface is plumb. A plumb-rule of this description may be easily made and is very accurate but is not so convenient as a rule with level glasses.



FIG. 2

The advantage of the leveling glasses in the plumb-rule is that the wind does not interfere with its action. In the case

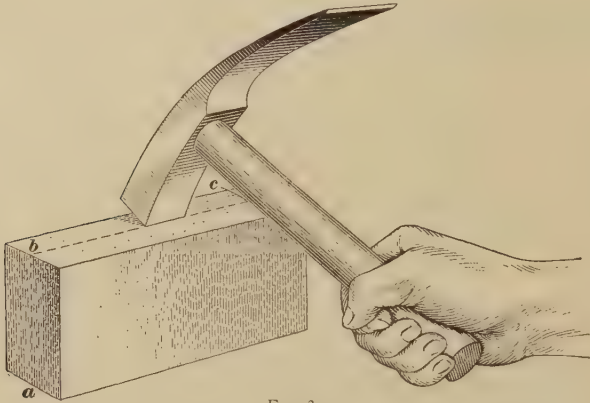


FIG. 3

of a plumb-bob suspended from a cord, even a small breeze causes motion of the bob, which interferes with its usefulness.

33. The principal tool used by a brickmason is the **trowel**, the form and use of which is illustrated further on in Figs. 8, 9, 10, and 11. These trowels are made from $9\frac{1}{2}$ inches to

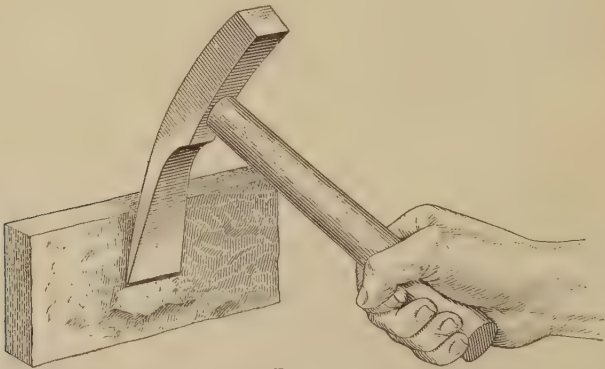


FIG. 4

11 inches in length. Pointing trowels are made from 4 to 7 inches in length.

34. A **cutting-out hammer** should weigh not less than $3\frac{3}{4}$ pounds and not more than 4 pounds, exclusive of the handle. There are many types of hammers that can be used for cutting out, but the one shown in Fig. 3 will enable a first-class man to do the most work with the least fatigue. In this figure is also shown the method of splitting a brick by means of the hammer. A line *a b c* is formed around the brick by means of light blows of the hammer and then a sharp blow is given which causes the brick to split at approximately this line. Any rough places on the split faces of the brick are trimmed off by the blade of the hammer, which is called the *peen*, or *pean*, as shown in Fig. 4.

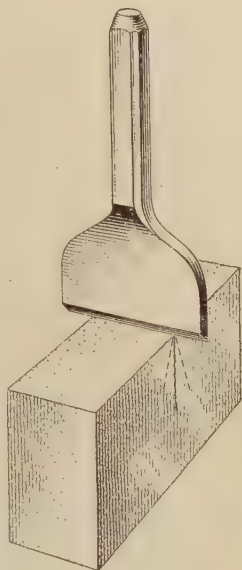


FIG. 5

35. A **brick set**, shown in Fig. 5, is a chisel with a broad cutting edge. It is used when it is necessary to make a cut having straight edges, so that the cut portion may show on the face of the wall, or to make plumb joints with adjacent bricks.

36. A **jointer**, shown in Fig. 6, is a tool that is used to form a true, even, and smooth surface on the face of the mortar between the bricks. Except where common bricks are exposed for effect this tool is not generally used, as the joints of mortar

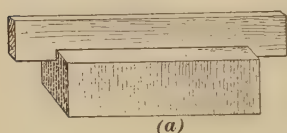


FIG. 6

are struck with the trowel as the work progresses; but a brick-mason should possess one for use in connection with such face

effects or face-brick work. Such a tool, at the very best, gets dull and loses its shape quickly, owing to the wearing action of the sand in the mortar, consequently it should be made of the hardest tempered steel that is obtainable. At *a*, *b*, and *c*, Fig. 6, are shown sections through jointers of different kinds. The edges of these jointers are curved or pointed so as to give different profiles to the mortar. The ends *d* and *e* of the jointer may have different sections, so as to be useful for striking two shapes of joints.

37. Wooden gauges, shown in Fig. 7 (*a*), are used to test the lengths of bricks when they are to be selected of a uniform size. The gauge shown in (*b*) is used when it is desired



(a)



(b)

FIG. 7

to cut bricks into smaller sections of uniform length. These tools are used for gauging face brick, but may frequently be used for common brick used in facing walls.

38. The line, chalk, and pencil are familiar but indispensable implements. Pieces of leather, called *leather protectors*, are used by some mechanics to protect their

hands when they are required to handle a great number of bricks daily.

39. Method of Laying Brick.—In connection with the laying of brick, certain terms are used. When a brick is laid with its length in the direction of the wall, as shown at *a* in Fig. 18, it is termed a *stretcher*; a brick placed crosswise so that its end is exposed in the face of the wall as shown at *b* in Fig. 18, is called a *header*. A *course* of brick may mean one horizontal layer of brick or it may mean one horizontal layer of brick and one horizontal mortar joint.

In America, most bricks are laid in what is known as the *American bond*, which is described later in this Section. This bond consists of a layer, or course, of headers and four or five courses of stretchers, then another course of headers, etc. In building brickwork of this kind it is customary to lay the

courses on the outside of the wall first. As many as five or six courses are laid before the bricks forming the inside of the wall are put in place. These outside courses are laid up plumb and level and serve as guides for the courses on the inside of the wall.

40. The first step in laying the wall is to build a portion at each end and see that these are plumb and that the courses at each end are level with the corresponding courses at the other end.

A mason's **line** is then stretched between these ends to serve as a guide in laying the brick in between. In Fig. 8 is shown a mason's line *c d* and the method of attaching it temporarily to

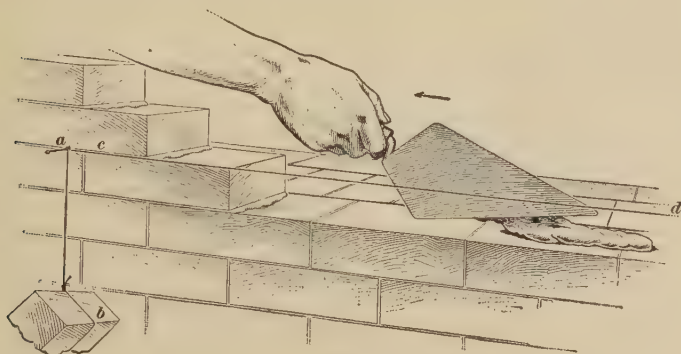


FIG. 8

the wall. This is done by driving a nail *a* into the mortar joint and winding the line around this once or twice. The line is held taut by tying a piece of brick *b* to the end. The line is secured in a similar manner to the corresponding course at the other end of the wall and bricks are laid in between so that their upper edges coincide with the line. By this method the wall is kept plumb and the horizontal joints straight and level.

When the work is interrupted for any length of time, the outer courses should not be higher than the backing, especially where face brick is used, as the mortar joints in the face of the wall will dry out too rapidly and the color of the mortar will appear different from that in other parts of the face of the wall.

41. In Fig. 8 is shown the actual process of laying brick in a 16-inch or 17-inch wall. A trowel with mortar on it is moved

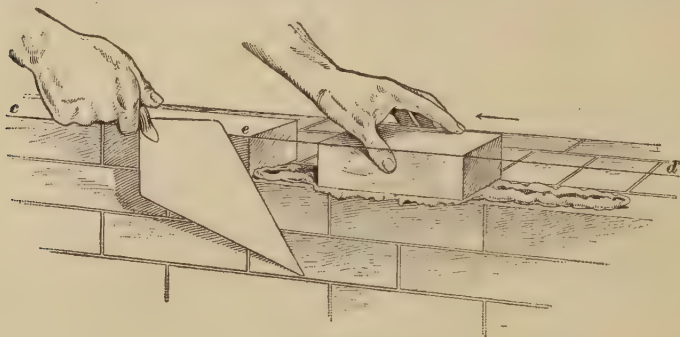


FIG. 9

over the wall in the direction of the arrow and at the same time is tilted so as to allow the mortar to slide off. This distributes the mortar over the outer course of brick in the wall. The mortar is then spread with the point of the trowel, which is drawn through the mortar with a vibrating motion of the hand which causes the mortar to form little ridges as shown in Fig. 9. A brick is then placed on this mortar bed about 3 or 4 inches away from the brick against which it is to be placed, as shown in Fig. 9, and is shoved into place as in Fig. 10. The shoving movement forces a quantity of mortar up into the vertical

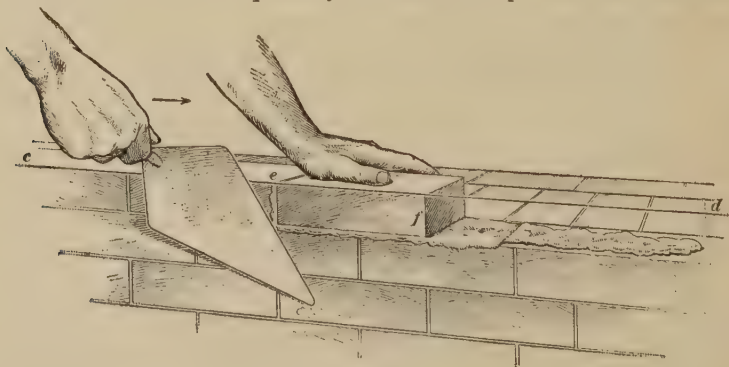


FIG. 10

joint *c*, Figs. 9 and 10, and squeezes out any excess of mortar that may be in the joints.

The upper edge of the brick should coincide with the line *c d*, which is the mason's line previously referred to. If this edge is too high, the brick is tapped down with the handle of the trowel or sometimes with the hammer until it is even with the line. If the top of the brick is below the line, the brick must be taken up and more mortar placed under it.

When the brick has been accurately placed, all the mortar which has been squeezed out while placing the brick and which projects beyond the face of the wall is removed by a stroke of the trowel as indicated in Fig. 10. This surplus mortar adheres

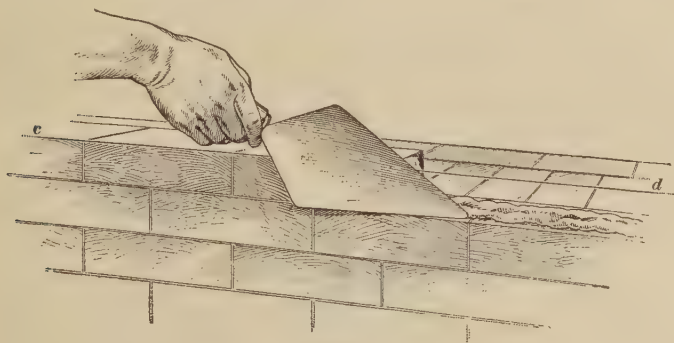


FIG. 11

to the trowel and is scraped off against the vertical edge of the brick as shown in Fig. 11.

42. After five or six courses have been laid on the face of the wall, the joints are all smoothed with a trowel, then the interior of the wall back of these face courses is begun.

The inside course is first laid in the manner described for the face courses and the mortar joints on the inner face of the wall are smoothed with the trowel. A bed of mortar is then placed between this course and the outer course and bricks are placed in the space quite rapidly, as it is not necessary that they be exactly placed. Bricks that are slightly chipped, warped, or that have slight defects are used in the heart of the wall with satisfactory results. Mortar is then filled in between these bricks from the top and another row, or course, is placed on top of the one just finished. Very often the joints in the interior of a brick wall are not completely filled with mortar, and where

the wall does not bear a heavy load this kind of work may be sufficient. In the case of piers and portions of wall that support great loads, it is necessary that all the interior joints in the wall be well filled with mortar.

43. Frequently, instead of laying the bricks on the outside of the wall with a shoved joint, as illustrated in Fig. 9, the bricks are laid right in place, as shown in Fig. 12, with only a small amount of mortar between their ends, such as has been scraped off the trowel. This joint should be afterwards filled by throwing mortar into the top of it from the trowel.

44. Laying Brick in Severe Weather.—When brickwork is erected in freezing weather, all the materials, as far as

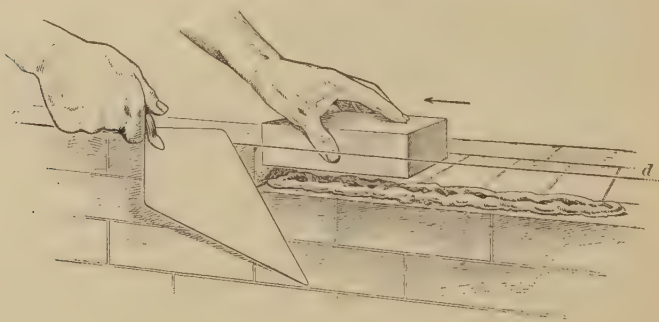


FIG. 12

possible, should be warmed. The brick should be thoroughly dry and in addition should be heated. The mortar should be warmed by using hot water and heating the sand. The scaffold and the wall may be enclosed in tarpaulins, which are large sheets of heavy cotton cloth, and inside the tarpaulin enclosure fires may be kept burning in salamanders, which are sheet-iron cylinders supported on iron legs.

The work should be carefully protected at night by coverings of boards or tarpaulin and should be protected from snow and rain until the mortar has thoroughly set.

Salt is sometimes added to the water with which the mortar is mixed, to prevent its freezing until a very low temperature occurs. The salt, however, is apt to appear later on the face of

the wall in the form of a white efflorescence which disfigures the wall.

In very hot weather the brick should be thoroughly wet with water sprayed on them from a hose. If this is not done, the brick will absorb water from the mortar, which will prevent its setting.

SCAFFOLDING

45. Inside Scaffolding.—In erecting brickwork it is necessary to build scaffolding as the work progresses. The contractor naturally uses the cheapest type of scaffold that will serve his purpose, and will always use an inside scaffold instead of an outside one if the character of the work will permit. The reason is that the floorbeams can then be used to support the scaffold and the scaffold will not have to be built up from the ground.

46. When a simple job of brickwork is to be done, such as a plain building, the bricks are generally laid from the inside so that the inside scaffold can be used. Boards laid upon the floorbeams serve as a scaffold for the wall up to a height of about 4 feet 6 inches. A scaffold consisting of wooden horses with planks laid upon them serves for laying the upper half of the wall of the story. This process is then repeated, the same horses and planks being used over again.

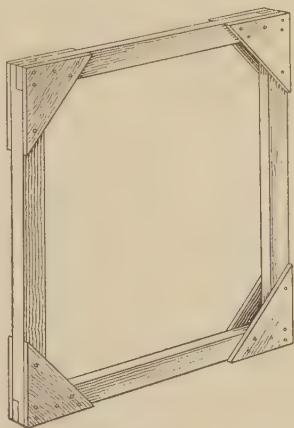


FIG. 13

47. Instead of wooden horses, square wooden frames, Fig. 13, braced at the corners, are often used. These are placed in an upright position and braced with boards placed diagonally. Planks are then placed on top of these frames.

48. Exterior Scaffolds.—Exterior scaffolding must be used when the outside face of a wall is to have an ornamental character or be trimmed with cut stone or terra cotta.

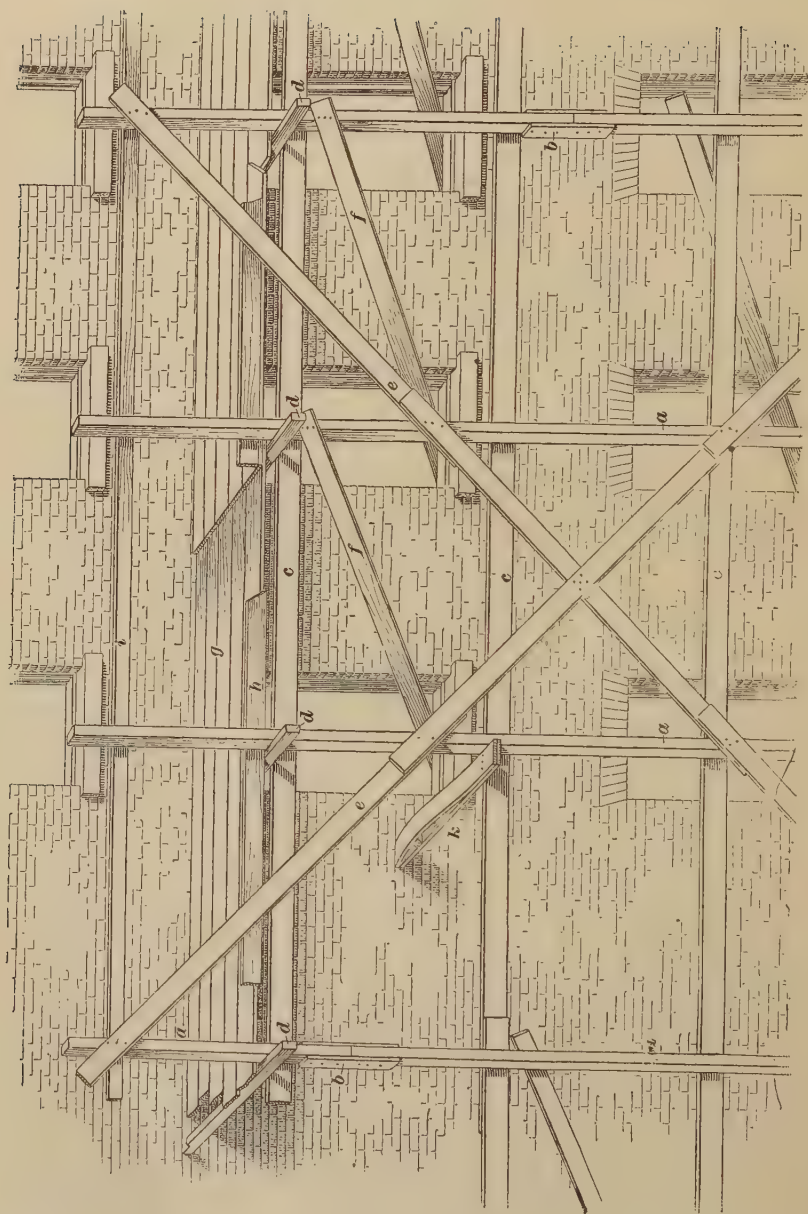


FIG. 14

The most common form of scaffolding used by masons is the **pole scaffold**. There are two types of the pole scaffold. One type depends partly upon the wall for support and the other type is built so as to be self-supporting and independent of the building.

A scaffold that receives some support from the wall is illustrated in Fig. 14. This scaffolding consists of uprights or poles *a*, which may be circular in cross-section, but which are generally in the form of small timbers, having a cross-section of 3 in.×6 in. for a five-story building and never less than 3 in.×4 in. The poles should be placed about 5 feet away from the face of the wall and about 7 feet 6 inches apart on centers. They should be firmly supported on the ground, and the lower ends should be braced so they will not slip. When they must be spliced together to make them longer, they are placed end to end and a piece of plank is nailed on each side of the joint as shown at *b*. These splices should not occur in all the poles at the same level. Ledger boards *c* are nailed to the poles to brace them horizontally and also to support the putlogs *d*, which sustain the floor of the scaffold. The other end of the putlog extends into the wall 4 or 5 inches. The uprights are braced diagonally by the braces *e* and to window frames by the window braces *f*. These latter braces prevent the scaffolding from falling away from the building.

What is known as a **spring stay** is shown at *k*. This device consists of two boards or planks, the ends of which are placed in a hole in the wall and a block is placed between them near to the wall. The block causes the boards to spread. The spread ends are brought together and nailed to the ledger. This action forces apart the ends in the wall so that they obtain a firm grip in the wall. The spring stay holds the scaffold firmly to the wall.

A platform *g*, formed of 2"×10" planks, which lap over each other at the ends, is laid on the putlogs. Foot-boards *h* are nailed on top of the platform against the uprights, also a guard-rail *i* is placed at a suitable height.

The entire structure should be thoroughly braced and well nailed with 10- or 12-penny nails.

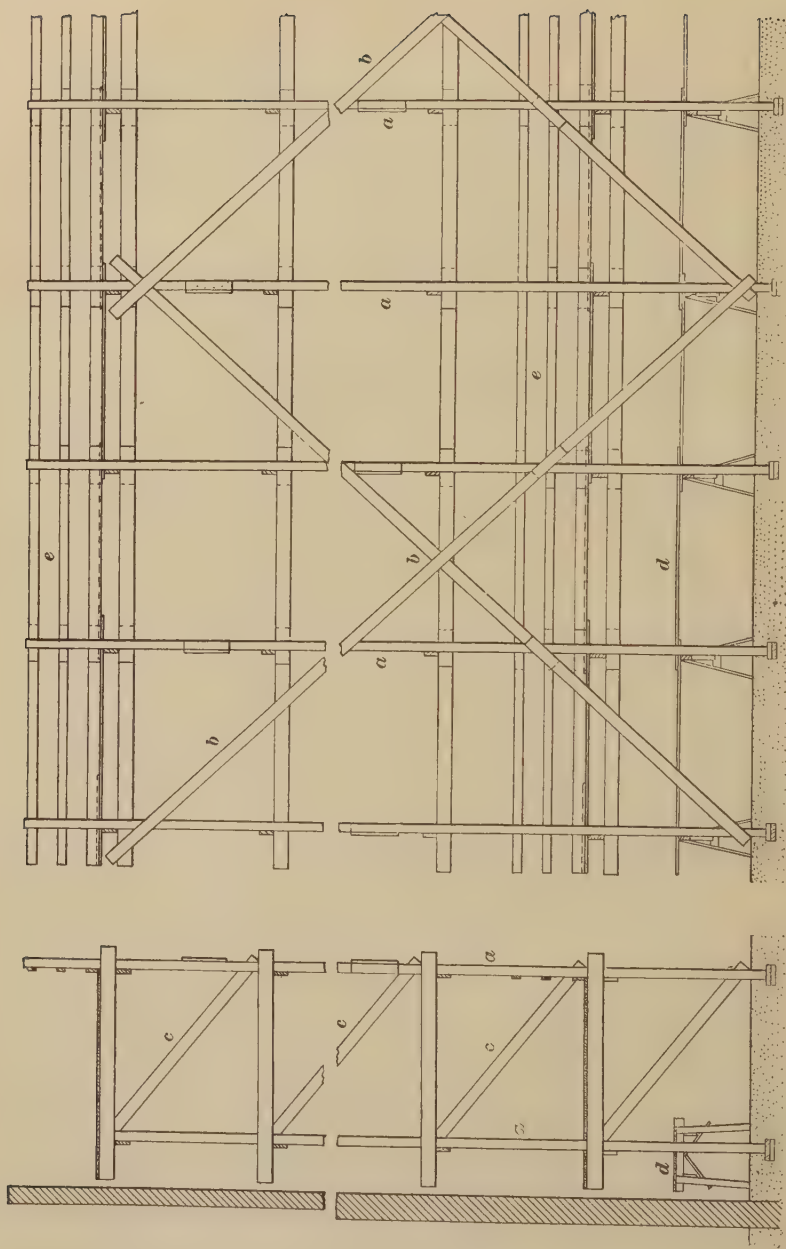


Fig. 15

49. A self-supporting pole scaffold is shown in Fig. 15. There are two sets of poles or uprights as shown at *a* in the side view. These are braced together, as indicated at *b* in the front view, as well as in a direction perpendicular to the wall, as at *c* in the side view. The planks of the working platform are carried on horizontal pieces which, as shown, do not touch the building. Putlogs are not used in this scaffold, as their use is likely to disfigure the face of the wall. It is always difficult properly to patch up the holes in the wall made by the putlogs, and for this reason it is desirable to use an independent scaffold. The upper part of the first-story wall is laid from the scaffold *d*, which consists of planks laid on horses. There are two guard rails shown at *e*. A scaffold of this description should not be used for a wall more than 100 feet in height.

50. A type of scaffold that is used when only one story of the wall, such as the cornice story, is required to be built from the outside, is formed by extending planks on edge out of the window openings and laying a platform upon them. Guard rails should be provided as in other scaffolds.

51. Suspended Scaffolds.—On tall, skeleton-construction buildings, suspended scaffolds are used. Steel beams called outriggers are supported on the floorbeams of the upper part of the frame of the building and project out 5 or 6 feet beyond the face of the wall. From these projecting beams the scaffold is suspended by means of wire cables. The cables are attached to the scaffold by means of devices by which the cable can be rolled up and the scaffold thus raised as required.

BRICK WALLS

TYPES OF BRICK WALLS

52. Solid Walls.—The brick wall most universally used and which is cheapest to construct is the *solid* wall. This wall consists of a solid mass of brickwork with no hollow spaces constructed in it. Such a wall is substantial, easy to build, and when properly constructed will last for centuries.

53. There are certain disadvantages characteristic of brick walls, and these result from the porosity of the brick and mortar. Unless a wall is built of good hard-burned brick and laid up with a properly proportioned mortar, moisture is likely to find its way through it. Some method is, therefore, generally adopted to prevent this moisture from reaching the inner surface of the brickwork, especially when plastering is applied directly to the brick.

54. One of these methods is to coat the inner surface of the wall with a damp-proofing compound which fills the pores on the inner surface of the wall and adheres strongly to the brickwork. At the same time this compound affords a good key for the plastering.

Another method is to form the inside 4 inches of hollow bricks or 8 inches of hollow tile, but while plastering applied directly to these surfaces will hold satisfactorily, the bonding courses of the joints are apt to become damp on the inside during wet weather.

55. The best and cheapest method of preventing water from reaching the plaster is to furr the walls. This may be done by nailing wooden **furring strips** about 1 inch by 2 inches in size to the inner face of the wall and nailing wood or metal lath to them to receive the plastering. Metal rods or furring may be stapled to the walls and metal lath fastened to them, or one of the several types of *self-furring* metal laths may be used. Terra-cotta furring may be applied to the entire face of the wall, such furring being held in place by the use of mortar and nails.

56. Hollow Walls.—Hollow walls, or more properly, double walls, are sometimes built and are intended to keep moisture from passing through, and by providing a complete separation of one wall from the other, keep the building cooler in summer and warmer in winter. Difficulties that largely offset their advantages are met with in construction, however, so that hollow walls are not often used in the United States. The objections to hollow walls are that more ground area is

required, thicker foundations are needed, the cost of construction is increased, and there is no assurance that the two walls are better than one solid wall properly furred.

57. Party Walls.—A **party wall** is a wall that separates two adjoining buildings and carries the floor and roof beams of both of them. The floor loads on party walls are twice as great as the load on any outside wall.

Building regulations in regard to the thickness of party walls are based on the span of the joists or width of building, and on the height. The specifications of the Committee on Building Construction of the National Fire Protection Association require all party walls and fire walls to be of solid masonry and almost all building codes require solid brick, not only as fire protection but to afford the property owner on each side the opportunity to insert or hang joists at any desired level or place.

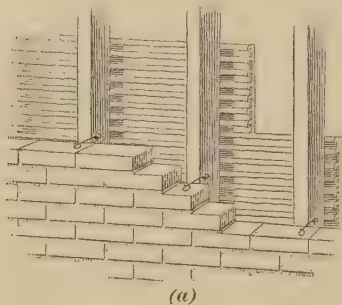
58. Fire Walls.—The National Fire Protection Association has defined a fire wall as follows: "The term **Fire Wall** indicates a wall subdividing a building to restrict the spread of fire. In all buildings it shall start at the foundation, be continuous through all stories and extend at least 3 feet above the roof."

59. Panel or Enclosure Walls.—In modern skeleton construction, the floor loads in a building are carried on the steel or reinforced-concrete frame, and the walls carry no load other than their own weight. Such walls are generally supported upon girders extending from column to column, usually at every floor. In this way much thinner walls can be used, and valuable space can be saved.

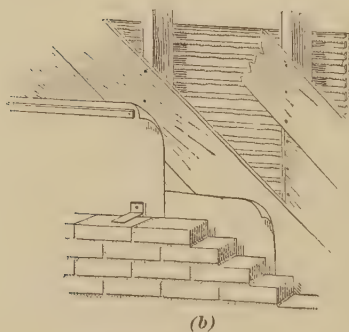
The New York City Building Code provides that "masonry walls supported at each story by girders may be 12 inches thick for the entire height of the building."

The Chicago building ordinances provide that "If buildings are made of fireproof construction, and have skeleton construction so designed that their enclosing walls do not carry the weight of floors and roof, then their walls shall be not less than 12 inches in thickness."

60. Curtain Walls.—Following is an extract in regard to curtain walls from the New York City building laws:



"Curtain Walls. Non-bearing walls built between piers or metal columns shall not be less than 12 inches thick for the uppermost 60 feet of height, increasing 4 inches in thickness for each next lower section of 60 feet." Curtain walls are not supported by beams, but rest on suitable footings supported on the foundation soil.



61. Veneered Walls.

Frame houses are frequently incased in a 4-inch veneer of brick, separated from the wood by a 1-inch or a 2-inch air space. Veneered walls are generally somewhat cheaper than those built of solid brick. Houses constructed in this fashion are warmer in winter and cooler in summer, and are also less likely to catch fire from outside sources than are ordinary frame buildings.

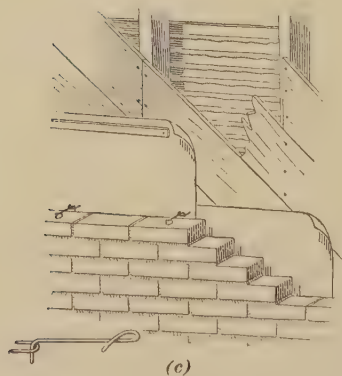


FIG. 16

62. In building a house with veneered walls, the foundation must project far enough beyond the line of the studs to carry the brickwork that is put on later. This requires a projection of 1 inch for sheathing, 1 or 2 inches for air space, and

4 inches for brick. The 1 or 2 inches allowed for an air space is also necessary to accommodate the mason's fingers

when he is laying the brick, and is frequently called a *finger space*.

Care must be taken to construct the frame in the best manner, for the brick veneer carries absolutely no part of the building except its own weight, and in fact has to be tied to the wood framing for support. After the frame is up it should be sheathed diagonally and the sheathing should, as a rule, be covered with tar paper or other waterproof material on the

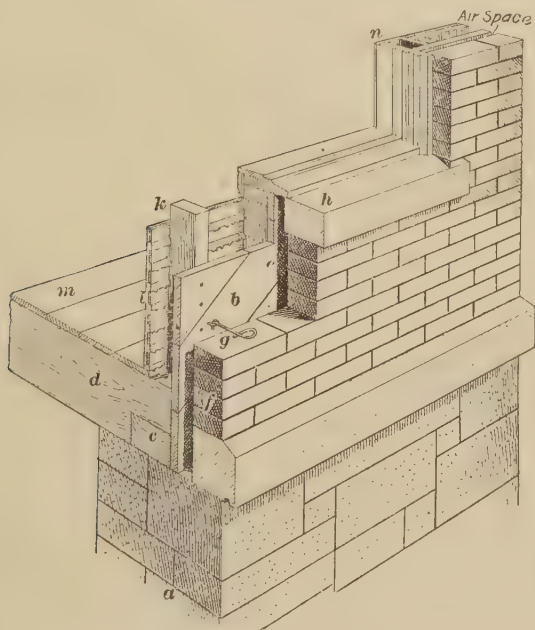


FIG. 17

outside before the bricks are laid. The sheathing is omitted in a very cheap form of construction such as is shown in Fig. 16 (*a*). This form of construction is not to be recommended, however. The tar paper is omitted in Fig. 17 for the sake of clearness. All the framing timber, particularly the sills, should be as dry as possible, and the frame must be perfectly plumb and straight; if not, the brick veneer will not lay up properly.

The brick veneer is usually tied to the diagonal sheathing or

to the studs with metal ties. The wire tie, shown in Fig. 16 (*a*) and (*c*), is most generally used, though a tie made of No. 16 iron, $1\frac{1}{4}$ inches wide, with the end turned up, as shown in Fig. 16 (*b*), gives satisfactory results. The ties are generally placed on every other brick in every fifth course of brickwork.

63. Fig. 17 shows a section through part of the foundation of a veneered building and the principal features of its construction. At *a* is shown the stone foundation wall, projecting 6 inches beyond the diagonal sheathing *b*; the 4"×6" sill is shown at *c*, the 2"×10" floor joists at *d*, and the air space between the brickwork and the sheathing at *e*. The 4-inch brick-veneer wall is shown at *f*, and the wire tie at *g*; the stone window sill is shown at *h*, the 2"×4" studding at *k*, the lathing at *l*, the flooring at *m*, and the window frame at *n*.

Due to the fact that any stability which a 4-inch brick veneer receives is dependent upon metal ties, which may rust, attached to a wooden building which may vibrate and will burn, this type of construction is not to be recommended, especially for any height above two stories.

64. Veneering on Hollow Tile.—Brick, especially face brick, may be used as a veneer on hollow building tile or back-up blocks. A wall of this description is generally damp-proof, and plastering can be applied to the inside face of the terra cotta without the danger of dampness affecting it. Such walls will be more fully described later in the Section on *Hollow Tile*.

THICKNESS OF WALLS

65. The thickness of walls in brick masonry is a matter that cannot be determined by calculations. Experience must be followed and also the regulations laid down in the building codes of different cities. The latter is the better plan, as the stipulations given in these codes are the result of experience of many men, and there are thousands of buildings to show the successful application of the rules given in these codes.

66. According to the New York City Building Code.—The New York Building Code makes the following

provisions for structures where the walls are entirely of brick and support the floors and roofs, and where no steel columns or beams are built into the walls:

Residence Buildings.—Except as otherwise provided, the thicknesses of brick walls of residence buildings hereafter erected shall be not less than the following: (a) When over 75 feet in height, 12 inches for the uppermost 25 feet, 16 inches for the next lower 35 feet, 20 inches for the next lower 40 feet, with a 4-inch increase for each additional lower section of 40 feet; (b) when not over 75 feet in height, 12 inches for the uppermost 55 feet, and 16 inches below that.

Public and Business Buildings.—Except as hereinafter provided, the thickness of masonry (brick) walls of public and business buildings hereafter erected shall be not less than the following:

(a) When over 75 feet in height, 16 inches for the uppermost 25 feet, 20 inches for the next lower 35 feet, 24 inches for the next lower 40 feet, and increasing 4 inches for each additional lower section of 40 feet.

(b) When over 60 feet and not over 75 feet in height, 16 inches for the uppermost 50 feet, and 20 inches below that.

(c) When over 40 feet and not over 60 feet in height, 12 inches for the uppermost 20 feet, and 16 inches below that.

(d) When not over 40 feet in height, 12 inches throughout.

Increased Thickness When Required.—(a) Every bearing wall with face brick bonded with clip courses or ties, and every bearing wall faced with ashlar, shall have a total thickness of at least 4 inches more than otherwise required unless the ashlar is at least 8 inches thick in every alternate course and bonded to the wall:

(b) When the clear span between bearing walls is over 26 feet, such walls shall be increased 4 inches in thickness for every $12\frac{1}{2}$ feet or part thereof that said span is over 26 feet.

(c) All walls over 105 feet long between cross-walls or proper piers or buttresses, shall be increased in thickness over the minimum requirements at least 4 inches for every 105 feet, or part thereof, over 105 feet in length.

(d) If the horizontal section through a bearing wall shows more than 30 per cent. area of flues and openings, such part of the wall where the excessive openings exist shall be increased 4 inches in thickness over minimum requirements for every 15 per cent. or fraction thereof, of flue or opening area in excess of 30 per cent.

General Reservations.—Nothing in these laws shall prevent the use in any wall of the same amount of material in piers and buttresses as is required for the thickness prescribed.

The unsupported height of any wall or part thereof shall not exceed 20 times the thickness of such unsupported part, unless reinforced by adequate cross-walls, buttresses, or columns.

67. According to the Chicago Building Ordinances.—The ordinances of Chicago group buildings into several classes and specify certain conditions that apply to these different classes. Where the walls of the buildings are entirely of masonry and support the floors and roof, the following general regulations are prescribed:

Brick, stone, and solid concrete walls, except as otherwise provided, shall be of the thickness in inches indicated in the following table:

Number of Stories in Building	Story												
	Basement	1	2	3	4	5	6	7	8	9	10	11	12
	Thickness of Wall, in Inches												
One.....	12	12											
Two.....	16	12	12										
Three....	16	16	12	12									
Four.....	20	20	16	16	12								
Five.....	24	20	20	16	16	16							
Six.....	24	20	20	20	16	16	16						
Seven....	24	20	20	20	20	16	16	16					
Eight....	24	24	24	20	20	20	16	16	16				
Nine.....	28	24	24	24	20	20	20	16	16	16			
Ten.....	28	28	28	24	24	24	20	20	20	16	16		
Eleven...	28	28	28	24	24	24	20	20	20	16	16	16	
Twelve ..	32	28	28	28	24	24	24	20	20	20	16	16	16

There are modifications in these thicknesses that may be made under certain conditions, and when building where this code is in force a copy of the ordinances should be obtained and carefully followed. For instance, certain provisions are made for the use of 8-inch or 9-inch walls in dwellings and other small buildings, and these and other provisions must be complied with where such laws are in force.

BOND IN BRICKWORK

68. Necessity for Bond.—To build a strong, substantial, and solid wall with such small pieces of material as bricks, requires a careful arrangement of the bricks in the body of the wall so that they shall be tied together and form a cohesive mass of masonry. Tying the bricks together is done partly by good mortar and largely by proper bonding. **Bonding** may be described as the process of laying bricks so that one brick shall rest on parts of two or three bricks below it. The *bond* in a wall is the result obtained by *bonding*. Brickwork that is not

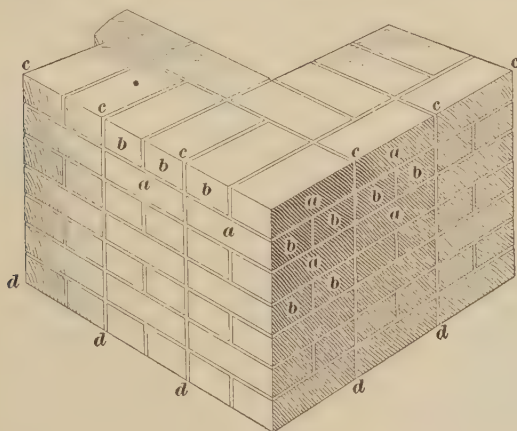


FIG. 18

properly bonded is shown in Fig. 18. By placing the brick in this manner, the wall is merely a series of piers that abut each other on the lines *c*, *d* and have no bond or union between them other than that obtained by the adhesion of the mortar.

The object of the standard bonds, that will be described presently, is to tie the wall together both longitudinally, or in the direction of the length of the wall, and transversely, or in a direction perpendicular to the face of the wall. The best brickwork is that in which the bricks are most thoroughly tied or bonded together, both lengthwise and crosswise, as well as vertically.

69. Terms Used in Bonding.—When brick are laid lengthwise in the face of a wall, as at *a* in Fig. 18, they are termed **stretchers**. When placed crosswise so that their ends are exposed in the face of the wall, as at *b*, they are called **headers**. A **course** means a horizontal layer of brick or one horizontal layer of brick and one horizontal mortar joint. Parts of bricks, that are made by cutting the whole brick, are called **bats** or **closers**. The different bats used in brickwork are shown in Fig. 19. A whole brick is shown in (*a*). When a brick is cut longitudinally, as in (*b*), on the line *a b*, each half is called a **queen closer**. It is difficult, however, to cut a brick in this manner, hence it is first cut on the line *c d e* and

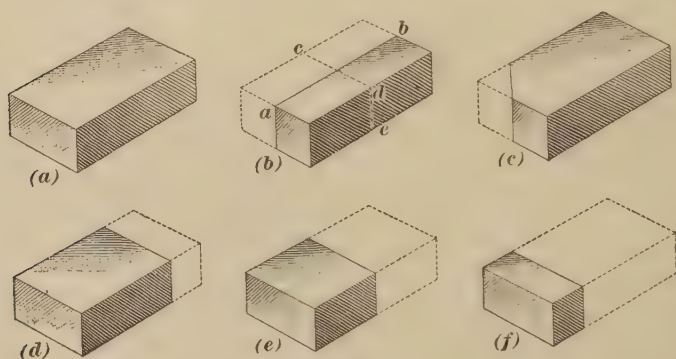


FIG. 19

each half is cut along the line *a b*. When a brick is cut as in (*c*), it is called a **king closer**. When one-fourth of a brick is cut off as in (*d*) the remainder is called a **three-quarter bat**. In (*e*) is shown a **half bat** and in (*f*) a **quarter bat**. A **closer** is a bat used to fill up a space near the end of a wall, resulting from the longitudinal bond used in the wall. Closers are illustrated in Fig. 20 at *c*.

70. Bonding is accomplished by lapping one brick over portions of two or more bricks in the course below. This process is often referred to as **breaking joints**. The vertical joints should not come one above the other in the face of the wall as shown in Fig. 18, but should alternate as shown in Fig. 20. This is done systematically so that the vertical joints shall

occur in plumb lines. The vertical joints in one course should be kept perpendicular, or directly over those in the second course below.

The joints in both faces of the wall should be directly opposite each other. This arrangement of the joints in the top of the wall is shown in Figs. 16, 21, 22, etc.

1353377

STANDARD BONDS

71. In the course of time there have been developed several standard methods of bonding brickwork such as the English, Flemish, American, Running, etc. bonds.

72. English Bond.—The **English bond** is probably the best and strongest method of bonding brickwork. In this

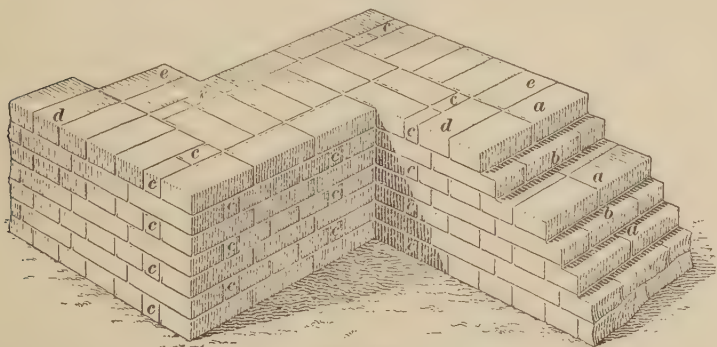


FIG. 20

bond, header and stretcher courses are laid alternately, as shown in Fig. 20. Joints are broken in the longitudinal bond courses by the use of quarter-bat closers, marked *c*. This is without doubt the best and simplest bond to use in all work where strength is required, as by its use a complete and thorough transverse bond is formed. It will be observed that the heart of this wall, which is about 16 inches thick, consists entirely of headers, and that the joints of the header course, as at *a*, are well bonded by the headers *b* of the stretcher course.

73. The wall shown in Fig. 20 has only two different courses. The arrangement of the bricks in these courses is

shown in Fig. 21 in courses *A* and *B*. By studying these plans in connection with Fig. 20 there should be no difficulty in understanding the construction of the wall. At *c* are shown

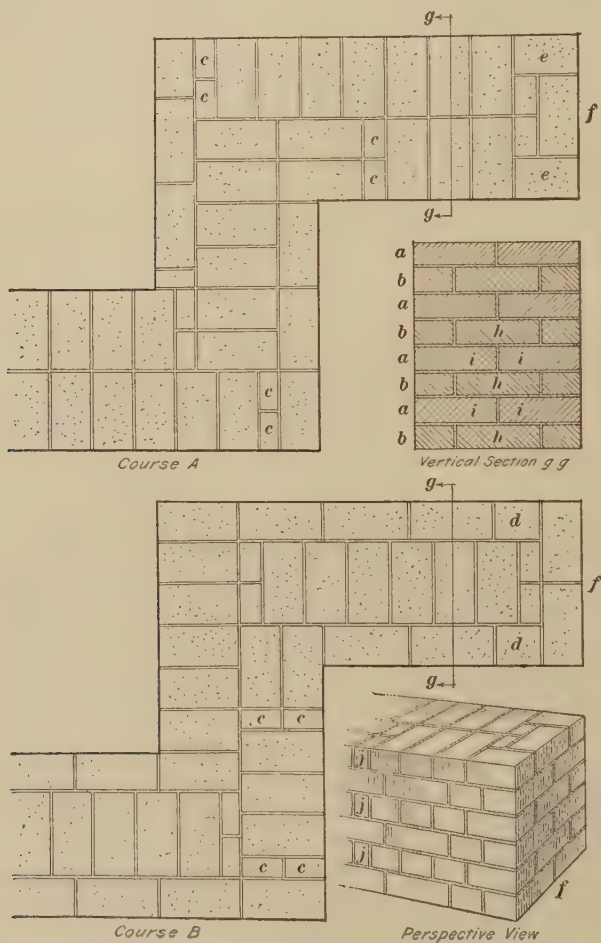


FIG. 21

queen closers; at *d*, half-bats; and at *e*, three-quarter bats. These latter are used in forming the end *f* of the wall.

In the vertical section through the wall taken through *g g* are shown the cross-ties formed by the bricks *h* lapping over

the bricks *i*. The perspective view shows the arrangement of the bricks in the face of the wall. The closers are shown at *j* and the end of the wall at *f*.

74. Flemish Bond.—The **Flemish bond** is one in which each course is composed of alternate headers and stretchers. The method of laying the bricks in this bond is illustrated in Figs. 22 and 23. Bats *a* and *b* are used at the corners of the walls and at *c* on the interior of the wall. In this example the headers and stretchers on the inner face of the wall are exactly opposite those on the outer face, and the wall is said to be built in **double Flemish bond**. The vertical section is taken through *e e* on the plans of the courses

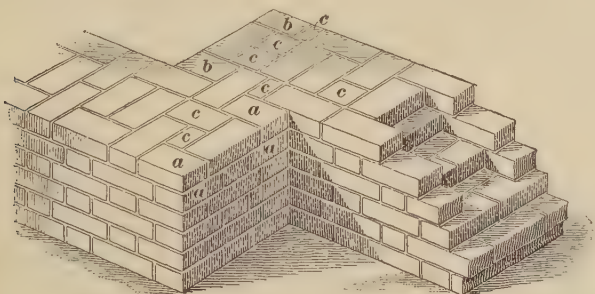


FIG. 22

A and *B* and shows the bond. The perspective view shows the appearance of the bond in the face of the wall and the jamb *f*.

75. American, or Common, Bond.—The bond most extensively used in the United States is known as the **American, or common, bond**. It is, in fact, a modification of the English bond. Instead of making every other course of brick a header course, as in the English bond, every fifth, sixth, or seventh course is made a header course in the American bond, with stretcher courses in between. This construction is illustrated in Fig. 24. Plans of the different courses are shown in Fig. 25, in which (*a*) and (*b*) are the courses that form the cross-bond, and (*c*) and (*d*) the stretcher courses in between. The arrangement of these courses is shown in the vertical sections (*f*) and (*g*).

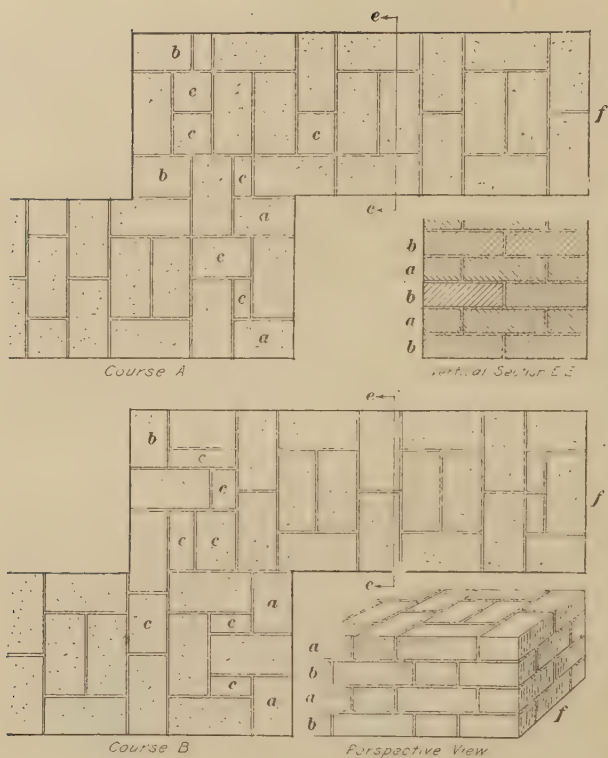


FIG. 23

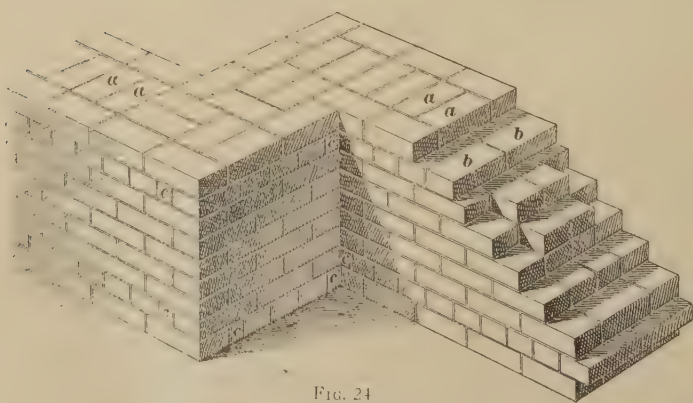


FIG. 24

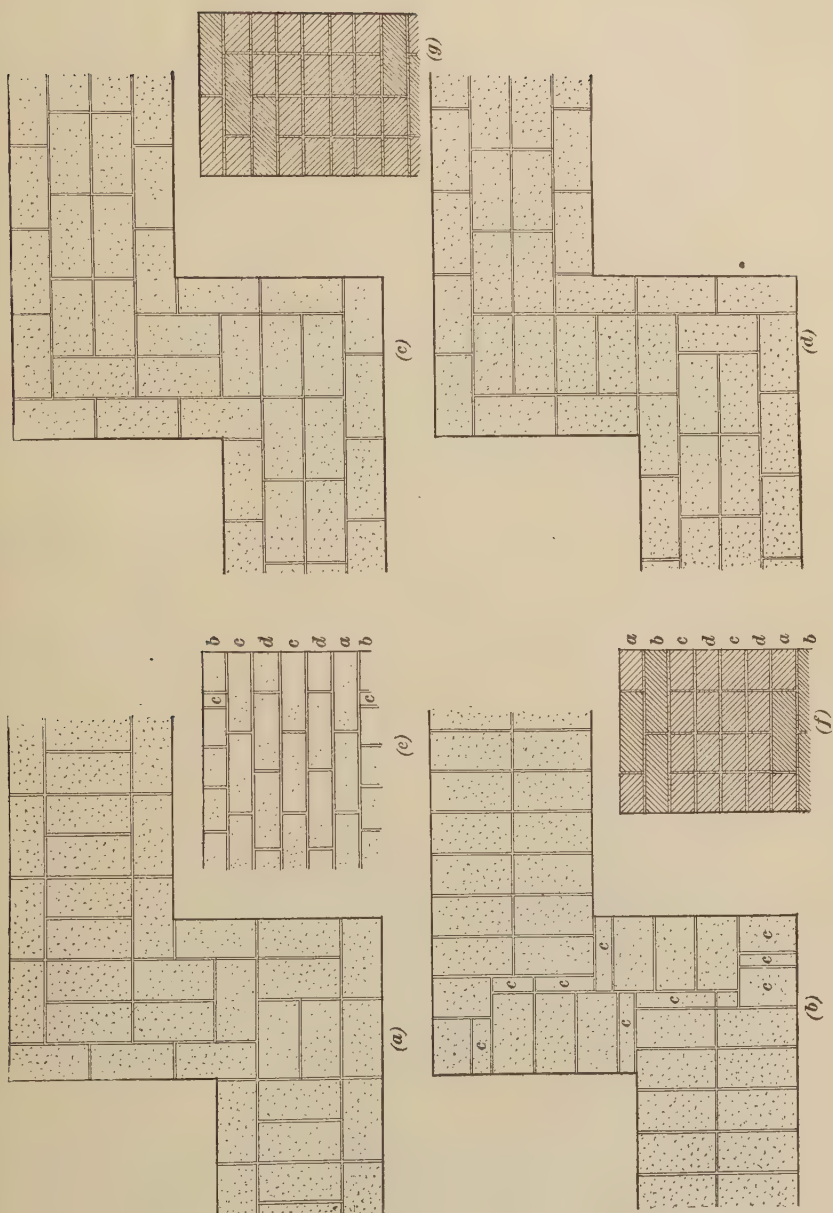


FIG. 25

The bond shown in (*f*) is formed by the two header courses *b* placed at the same level on the outside and inside faces and a course *a* lapping over both headers. This treatment brings the heading courses at the same level on both sides of the wall.

In (*g*) is a slightly different arrangement which is often used. In this case the header course on one side of the wall is lower than the header course on the other side.

The courses (*a*), (*b*), (*c*), and (*d*) are laid out according to the section (*f*). The arrangement of the bricks in the face of the wall is shown in (*c*). This form of bonding makes a wall that can be quickly and therefore cheaply built.

76. American bond is generally used in the United States not only for building walls of common brick, but also for backing up terra cotta, stone, and face brick. In fact the backing up is the real wall that not only supports the floor and roof loads, but also the weight of the facing.

The New York building laws require that every sixth course shall be a header course; that is, that five courses of stretchers must come between two courses of headers. For factory and warehouse purposes, where the walls have to sustain heavy weights, it is better to have every fourth course a header course, thus giving three courses of stretchers between the header courses.

BONDING FACE BRICK

77. Stretcher or Running Bond.—When a facing of brick is applied to a wall of common brick it is necessary to tie the facing firmly to the *backing*, or common-brick wall. This is done in different ways. When the facing is in running or stretcher bond there are no headers appearing in the face of the wall. In this case galvanized metal ties are generally used as shown in Fig. 26.

78. Face Bonds.—English and Flemish as well as other ornamental bonds are often used as facings only and are secured or bonded to a wall that is laid up in American or common bond. This can easily be done by extending some of

the numerous headers of the face bonds into the backing and thus securing an ample tie. The remaining headers will be composed of half-bricks or bats.

79. Metal Ties for Brickwork.—Fig. 26 illustrates the method of bonding in face brick with steel or galvanized-iron

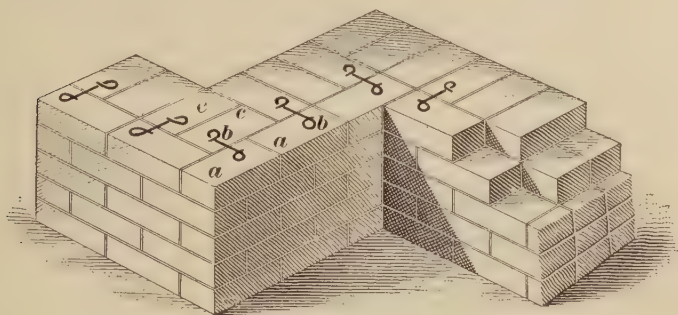


FIG. 26

wire. These wire ties *b* are twisted at the ends, and hold together the inside and outside courses *a* and *c*, as shown. They are laid in every sixth course of brick.

A still better method of tying front brick to the common brick in the rear of the wall is by the use of galvanized steel

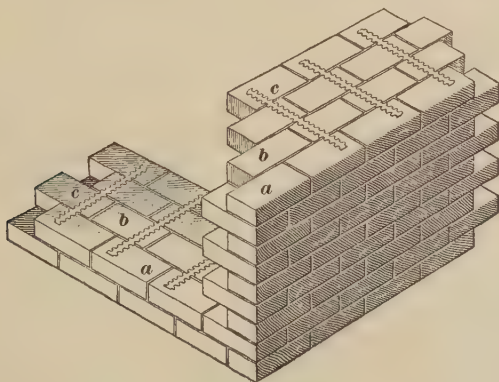


FIG. 27

ties from $\frac{3}{8}$ to $\frac{1}{2}$ inch thick, and having some of the metal punched out. The brick may be brought down to a very close joint, and the clinching edges make a very firm and satisfac-

tory binder. Fig. 27 shows the application of these bonding strips. Here, *a* is the pressed-brick facing, *b* the common brick in the rear of the wall, and *c* the steel ties bonding the pressed brick to the common brick.

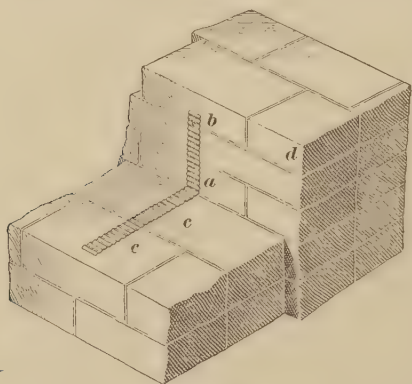
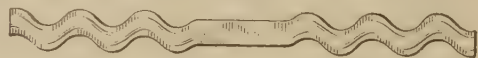


FIG. 28

Similar ties can be used for tying a new wall to an existing wall to increase its strength. The tie is bent near the middle, as shown at *a* in Fig. 28, and is nailed to the old wall with pointed wrought-iron nails, shown at *b*. These nails have

large flat heads made especially for this work, and are of sufficient size to make a firm connection for the new courses *c*.

Other forms of metal ties that are on the market are shown in Fig. 29. In using such ties it is generally advisable to use those that are sold in the local market.



BONDING HOLLOW WALLS

80. Before the introduction of metal ties, the bond between the two walls which form the hollow or double wall was accomplished with brick which were embedded in both walls and extended between them, tying them together.

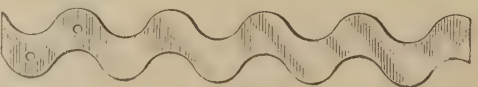
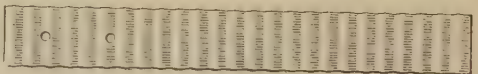


FIG. 29

This method was very expensive, as it required considerable cutting of brick. It also reduced the effectiveness of the hollow wall, as it provided places in the bonding brick through which dampness might pass.

81. Bonding With Metal Ties.—Bonding hollow walls by the use of metal ties is the cheaper and probably the better method, provided the ties are thoroughly protected from cor-

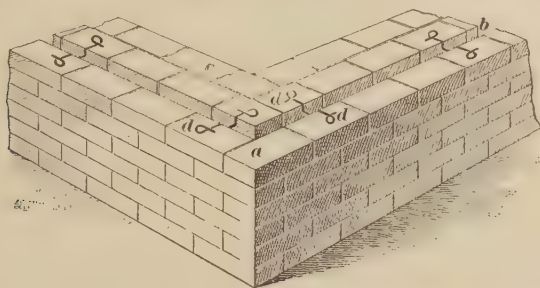


FIG. 30

rosion by galvanizing. These ties make the hollow wall effective, as the ties will not carry moisture to the inner wall.

At *a*, Fig. 30, is shown a 4-inch wall; at *b*, the air space; at *c*, the inner 8-inch wall; and at *d*, the metal ties. It should be said that hollow walls are not built very frequently, as the same results can be obtained at less cost by using hollow terracotta tile, called back-up tile, with a veneering or facing of brick.

BONDING WALLS AT ANGLES

82. In building brick walls, it is necessary that the angles in the walls be properly bonded. When the two walls forming the angle are carried up at the same time, the bonding at the corners is easily effected; if, however, one wall is built first, due to a delay in getting materials required for the other wall, particular care must be taken that the two parts will bond together properly.

In such cases, the wall first built is generally left toothed, as shown in Fig. 31.

In order to unite the two walls more firmly, anchors made of $\frac{3}{8}'' \times 2''$ wrought iron, with one end turned up 2 inches and the other turned around a $\frac{5}{8}$ -inch bar, should be built into the side wall about every 4 feet in height, as shown at *b*,

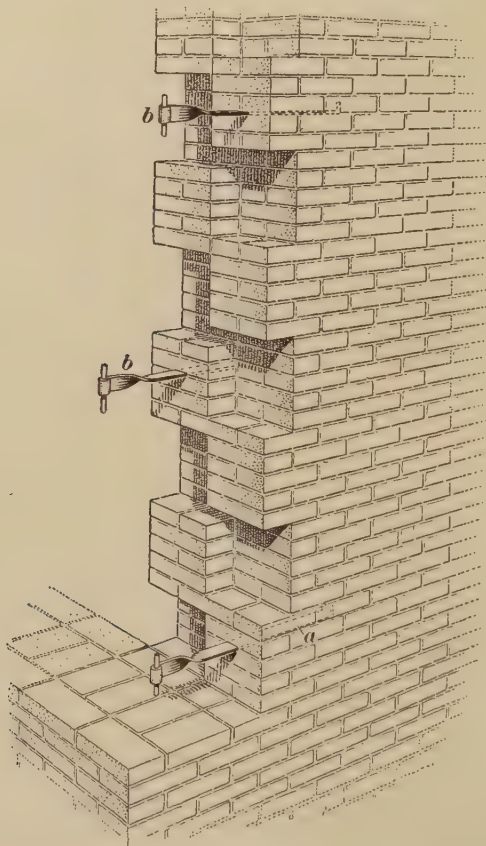


FIG. 31

Fig. 31. These anchors should be long enough to extend at least 12 inches, or the depth of one and one-half bricks laid the long way, as shown at *a*, into the side wall, and the center of the $\frac{5}{8}$ -inch bar should be about 8 inches from the back of the front wall.

JOINING NEW WALLS TO OLD WALLS

83. In joining a new wall to an old, a groove should be cut perpendicularly in the old wall, usually the width of a brick, so as to make a joint; this is called a *slip joint*.

This method of bonding is shown in Fig. 32. At *a* is shown the groove or chase cut where the new wall is to enter in the old wall; *c* is the new wall, and *d* the old wall.

In cheap construction, where new work is bonded into old, the method most commonly used is to nail a piece of

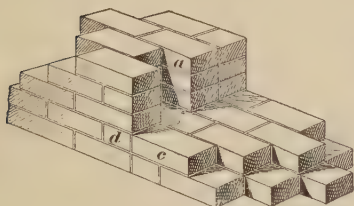


FIG. 32

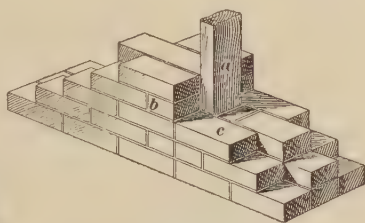


FIG. 33

2"×4" timber against the wall, as shown in Fig. 33, where *a* shows the 2"×4" timber spiked to the old wall and entering the center of the new wall. At *b* is shown the old and at *c* the new wall.

OPENINGS IN WALLS

84. Openings in Solid Walls.—When a brick wall contains door and window openings, their location and relative position should be very carefully considered, not only with regard to convenience and symmetry, but also with regard to their effect on the strength of the wall. When walls are broken frequently by windows and other openings, cracks are more likely to occur than when the wall is plain and unbroken. This is owing to the unequal pressure on the wall. If walls are well bonded and anchored, the danger of cracks will be reduced to a minimum. When possible, the window openings in the different stories should be placed directly over one another.

Unless absolutely necessary, the placing of windows under a pier or directly over a narrow mullion should be avoided. When such a design must be used, brick arches or metal beams, or both, should be built in if the span is great or the arch a *flat* one.

In any bearing wall carrying the ends of floorbeams, the combined horizontal area of openings should not be more than one-third the total horizontal area of the wall, unless the thickness of the wall between the openings is increased by the use of pilasters, or buttresses.

85. Relieving Arches.—Openings may be spanned at the top by means of arches or lintels. Lintels cannot be made

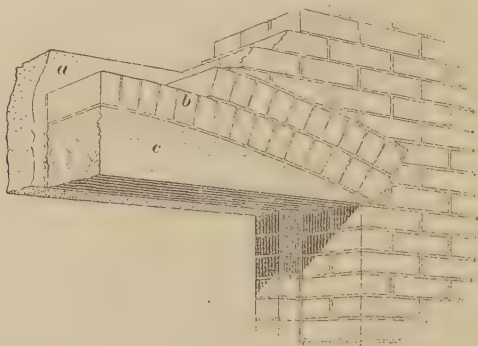


FIG. 34

of brickwork and are generally made of stone or reinforced concrete or a combination of metal and brick as described in the preceding article. When stone lintels are used they are generally only 4 inches in thickness and the remaining thickness of the wall must be supported either by steel or by brick **relieving arches**, such as shown in Fig. 34. These arches *b* are built upon solid wooden centers *c*, which are left in place after the arch is completed. The stone lintel is shown at *a*. Bricks laid in the manner shown at *b* are called *rowlocks*, and such arches, being made of two or more rows of rowlocks, are called *rowlock arches*.

BRICK ARCHES IN GENERAL

86. Arches should be laid up in cement mortar by careful and experienced workmen, or otherwise there is danger of the arches failing and letting down the weight imposed on them.

87. Definitions of Terms.—The following definitions of terms used in connection with arches are given. They may be readily understood by referring to Fig. 35.

Span.—The distance between the abutments, as shown at *a b*. The word *span* is also used to mean the material construction that spans, or covers, an opening or a gap.

Springer, or Skewback.—The stones or bricks that lie

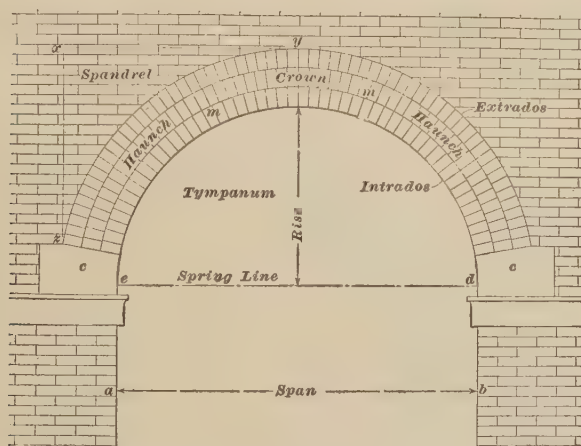


FIG. 35

immediately on the imposts, as at *c, c*, from which the arch proper springs.

Spring Line.—A line drawn through the points where the arch intersects the abutments, or where the vertical supports of the arch terminate and the curve begins, as shown at *e d*.

Intrados.—The lower concave surface of the arch, formed by the under sides of the bricks, although considered by some authorities to be the concave line at the edge of the under side of the bricks.

Soffit.—The lower surface of the arch, or the intrados.

Extrados.—The upper convex surface of the arch formed by the outer sides of the bricks in the arch; also, considered by some authorities as the convex line of the curve of the outside of the arch.

Rise.—The perpendicular distance from the spring line to the highest point of the intrados.

Arch Ring.—The arch itself, contained between the intrados and the extrados.

Crown.—The highest portion of the arch.

Haunches.—The portions of the arch included between the crown and the skewbacks.

Tympanum.—The space between the spring line and the intrados.

Spandrel.—The triangular wall space included between the extrados, a horizontal line drawn through the top of the

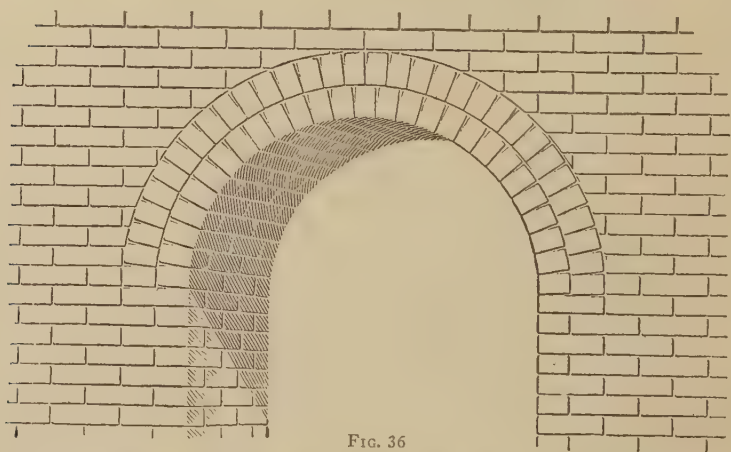


FIG. 36

extrados, and a vertical line drawn through the lower extremities of the extrados. This term is also applied to the space between two arches in a series of arches. The spandrel is shown at *z x y*.

Spandrel Filling.—The brickwork filling the spandrel.

Rowlock.—One of a series of arch courses, or rings, shown at *m, m*. There is no bond between these rings other than that afforded by the adhesion of the mortar.

88. Construction of Arches.—When semicircular arches are constructed of common bricks, the bricks are laid close together on the intrados, with wedge-shaped joints on the face of the arch; that is to say, the mortar joints are wider at the upper surface of the brick ring than at the lower surface, so that there is more mortar at the top of the joint than at the bottom.

Fig. 36 shows a semicircular arch consisting of two rings of rowlocks. These arch bricks are all laid as headers, and the long edges of the bricks show in the soffit of the arch. The increase of the thickness of the mortar in the joints is shown in the illustration.

89. Arches made of common brick are generally rowlock arches, and the difference in thickness of the joint in a distance of the width of one brick is not objectionable. An arch formed of bricks set with the length in the direction of the radius would require a decidedly greater thickness of joint toward the extrados than at the intrados. It is sometimes desired to use brick in this manner in connection with rowlocks in order to form a bond in the arch. In such cases it is necessary to have the bricks made to a radius, or wedge-shaped. Such bricks are called *gauged* or *shaped* bricks.

90. Gauged Bricks.—Fig. 37 shows a semicircular arch constructed of *gauged*, or *shaped*, bricks. The gauging, or shaping, may be accomplished by laying out the arch ring on a floor, and cutting, rubbing, or grinding the bricks to a certain gauge, or pattern, so that each brick will fit exactly in the place chosen for it; and all the mortar or radial joints will be of the same thickness throughout. This process is, however, expensive, and where there are many arches the brick should be molded in the required shape when manufactured.

In the example shown in the illustration, the space under the arch is filled by a brick wall supported on a bluestone lintel. This allows the bronze doors underneath to be made square on top.

As seen by the illustration, the extrados of the arch is stepped into horizontal steps. This is done so that the bricks



FIG. 37

in the wall will not have to be cut down to a knife edge in order to make them fit the work.

When the *reveal*, or space between a window or door frame and the outside of the wall, is only 4 inches, gauged-brick arches do not usually have any bond in the body of the wall except where metal ties are used; therefore, the bricks in the arch should be laid with great care and accuracy.

The class of work shown in the illustration is not often done in common brick, but is sometimes required in that material. The illustration shows the forms of bricks that will be required in such cases.

CHASES AND FLUES

91. Vertical grooves called *chases* and *flues* are frequently built in brick walls to receive plumbing, gas or heat

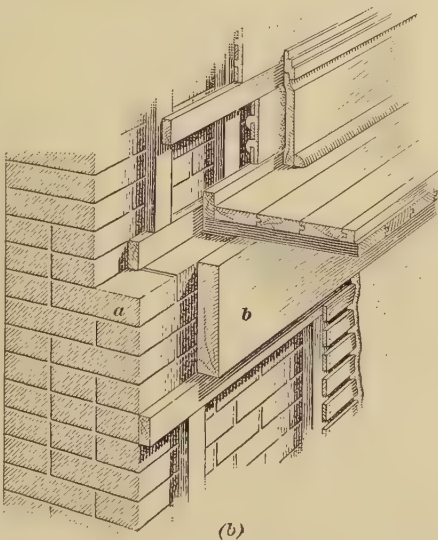
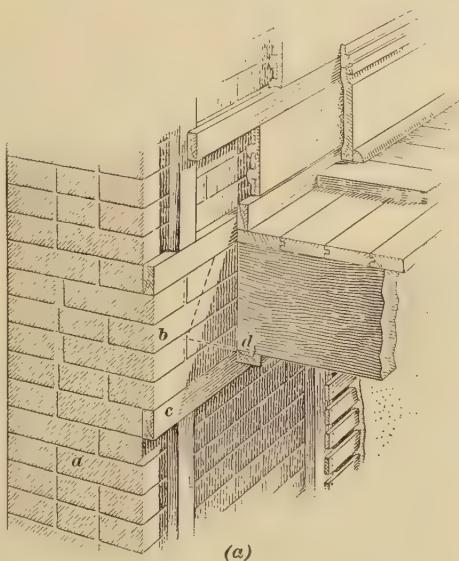


FIG. 38

pipes, etc. The building laws in some cities limit the number and size of chases that may be used in brick walls. For instance, the ordinances in force in New York City require that pipe chases shall not extend into any wall for more than one-third of its thickness and shall be not more than 4 feet in length measured horizontally. In the same ordinances, the areas of chases are counted in the areas of openings.

92. Fire-Stops.—Brickwork may be used to advantage as **fire-stops** to prevent the passage of flames from one floor to another back of the plastering. Brick walls are generally furred 1 inch, and this space, if continuous from floor to floor, permits the rapid spread of flames through the building.

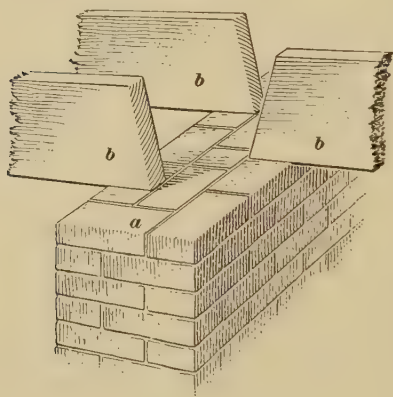


FIG. 39

Fig. 38 indicates a method of corbeling out the wall at the floor joists so as to close entirely the space between the wall and the plaster. At *a* in (a) is shown a wall of uniform thickness with the brick corbelled out at *b* for a fire-stop. A furring strip *c* makes a close joint with the cross-furring strip *d*. In (b) the brickwork sets back 4 inches, as the wall decreases in thickness at that point, as

at *a*, and *b* is a joist parallel to the wall. The wall should be carried up the full thickness to the top of the joists, and this will close all passages from floor to floor back of the plastering.

Where fire or party walls occur, the joists or beams should not be placed directly opposite each other, but should be staggered, as shown in Fig. 39. For adequate protection not less than 6 inches of brickwork should separate the ends of wooden joists. In Fig. 39 *a* represents a 12-inch wall supporting 2-inch joists on 16-inch centers. The joists *b* bear 4 inches on the wall and their ends are separated about $7\frac{1}{2}$ inches. With 3-inch joists similarly placed the ends of the

joists would be separated about $6\frac{1}{2}$ inches. Particular care should be taken to fill all joints in the brickwork with mortar, as unless this is done fire will find its way through from the end of one joist to the end of the other. In some cases it is difficult to secure 6 inches of brickwork between the ends of the joists, and in some cases steel beams may be used to secure the proper fire protection.

BACKING UP

93. As has been stated, common brickwork is frequently used in *backing up* stonework, terra cotta, and face brick. When this work is to be done, the stonework and terra cotta should be designed so that the heights of the courses shall be equal to the height of a definite number of brick courses, in order that the anchors or metal ties can extend back into the wall properly. For instance, with a customary size of brick, one course is counted as measuring $2\frac{1}{2}$ inches. The stone or terra cotta should be laid out in courses that are multiples of $2\frac{1}{2}$ inches in height. For instance, stone or terra-cotta courses should be made $7\frac{1}{2}$, 10, $12\frac{1}{2}$, 15, or $17\frac{1}{2}$ inches in height.

When a wall is faced with face bricks of other size than the common bricks used for backing, if the joints of the face brick are kept fine and those of the common brick thick, or vice versa, the courses will work out to the same height and permit of easy bonding every five to seven courses. As some Building Codes require frequent bonds, their provisions should be ascertained and bricks selected accordingly.

The same precaution should be taken in designing stone quoins, such as are used at corners of walls. The quoins should be designed to be a certain number of courses in height so that the bed joints of the stone will coincide with the joints on the brickwork.

EFFLORESCENCE

94. Very often, on buildings of stone or brick, more particularly the latter, white stains will appear on the surface of the walls after a few days of wet weather. These stains are

called **efflorescence**, and are due to certain soluble substances in the brick or mortar, or both. Carbonate of soda appears most frequently on new walls, and is due to the action of the lime in the mortar upon the silicate of soda in the bricks. Silicate of soda seldom occurs in bricks unless a salt clay is used in making the bricks. Sulphate of magnesia is formed when the clay contains pyrites, or when sulphurous coal is used for burning.

Water may reach the interior of the wall through absorption by the brick, through cracks and unfilled joints in the brickwork, through joints in the upper surfaces of copings or projecting courses, or from leaking or overflowing gutters and leader pipes back of the wall. When once the surface of the wall is penetrated, the moisture follows the joints and percolates to lower levels and to the outside surfaces, finally depositing the soluble substances by evaporation as stains or efflorescence.

Efflorescence may be prevented by the selection of impervious brick free from soluble materials, by filling all joints with mortar, by providing the upper surfaces of copings and projecting courses with overhanging coverings having drips, and by the proper design and maintenance of gutters and leader pipes.

Usually it is possible to remove efflorescence by washing the walls with a dilution of muriatic acid in 20 parts of water, which must be afterwards washed off with clean water. Several preservative coatings are designed to be applied to the walls after they are cleaned and dried. These preparations, by closing the pores in the brickwork, prevent the absorption of moisture. To be permanently effective, however, several coats must usually be applied, followed by additional coats at 2- or 3-year intervals.

HANGERS, ANCHORS, ETC.

95. The use of joist and girder hangers, etc. simplifies greatly the work of framing, both for house and mill construction. With these hangers and anchors, a good and firm bearing may be had in brick walls. The chief requisite of a good hanger is that it shall hold firmly to the wall and at the same

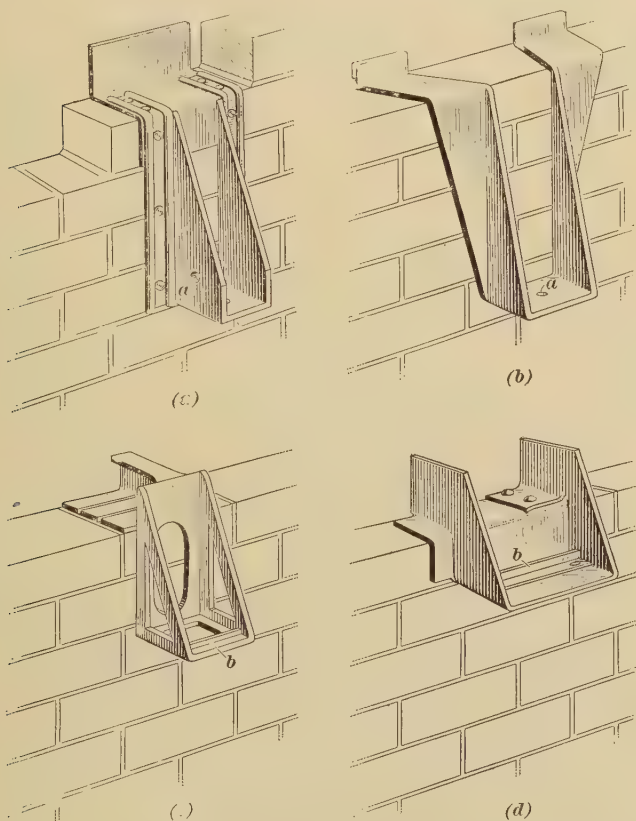
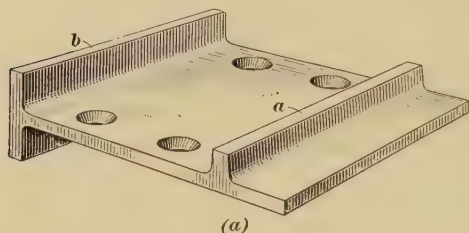


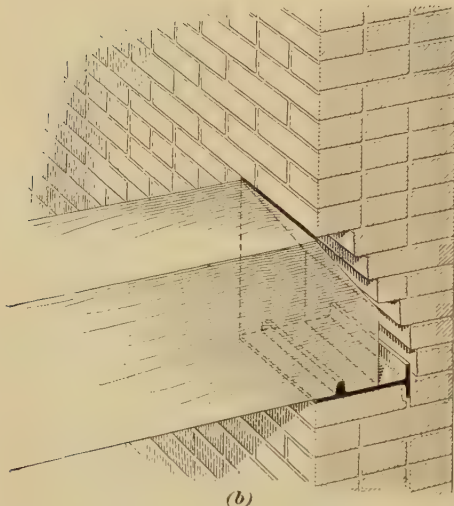
FIG. 40

time hold firmly to the joist. Fig. 40 illustrates four styles of hangers used to support joists and beams against brick walls. In none of these styles does the joist enter the wall, but rests in the socket; the top of the hanger being built into the wall.

In the hangers shown in (a) and (b), the joist is held in place by one or two spikes or lagscrews driven through the hole *a* of the hanger and into the wood. In the hangers shown in (c) and (d), there is a ridge, or lug, *b* on the hanger. A notch is cut across the bottom of the joist and the ridge of



(a)



(b)

FIG. 41

metal fits into this notch. The hangers in (a), (b), and (d) are made of sheet steel stamped and bent into shape, while that shown in (c) is of cast steel. The hanger shown in (a) is known as a **Van Dorn** hanger; the one in (b) is a **Lane** hanger; and those in (c) and (d) are **Duplex** hangers. These hangers also act as anchors, as the end of the beam is held from moving horizontally either by spikes or by the lugs of the hangers. At the same time if the middle of the joist should fail and drop by overloading or by

96. In Fig. 41 is shown a wall plate that is used for wooden beams or girders that extend into the wall. In (a) is shown the bearing plate with the lug at *a* and the flange *b* which turns up and down into the wall. The beam is usually finished with

a bevel cut on the end, known as a **fire-cut**. This cut allows the beam to fall out of the wall without injury to the wall. The fire-cut is illustrated in (b).

97. In Fig. 42 are shown the four forms of iron anchors that are used for fastening beams in brick walls. The one

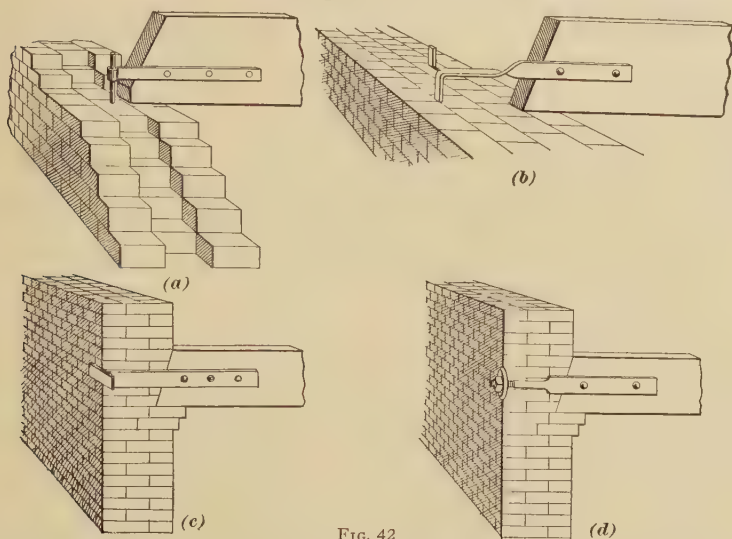


FIG. 42

shown in (a) is made of $\frac{1}{4}'' \times 1\frac{3}{4}''$ iron, about 2 feet long; the end built in the wall is made of a $9'' \times \frac{5}{8}''$ rod with the end of the anchor bent around it.

The anchor in (b) is made of $2'' \times \frac{3}{16}''$ iron, 2 feet long; the end that goes in the wall is cut as shown, and about 4 inches is

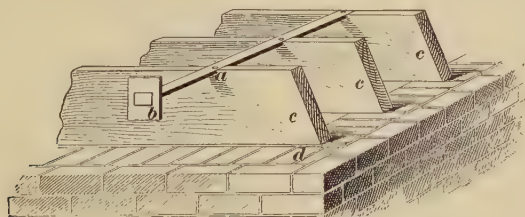


FIG. 43

turned at right angles to the anchor; the other end is twisted so that it can be nailed to the side of the joists.

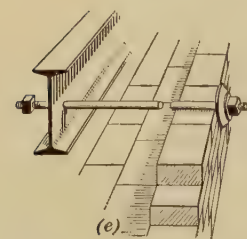
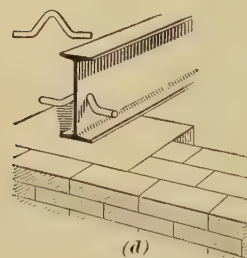
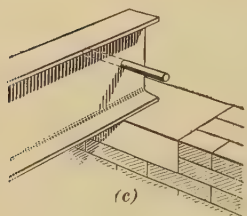
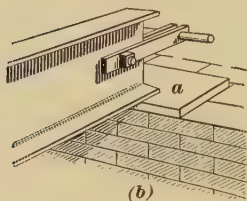
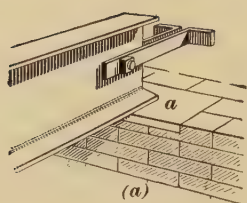


FIG. 44

An anchor that runs entirely through a wall is stronger than one that is simply embedded in a wall. On the other hand, the end of an anchor on the outside of a building makes an unsightly appearance. In warehouses and in back walls of buildings, however, when neat appearance is a secondary consideration, an anchor like that shown in (c) is used. It is made of $1\frac{3}{4}'' \times \frac{1}{4}''$ iron, 2 feet 6 inches long, and has a plate of $2'' \times 4'' \times \frac{1}{4}''$ iron forged on the outer end. This style of anchor may also be used in the middle of a wall in the same manner as those shown in (a) and (b).

In (d) is shown probably the strongest form of anchor. This style of anchor is made by flattening out a $\frac{3}{4}$ -inch bolt so as to make a $2'' \times \frac{1}{4}''$ portion to spike to the joist, and it is provided with a 5-inch cast-iron washer. A nut is placed on the outer side of the washer so that the anchor may be tightened up if necessary after the walls are built.

Anchors should always be spiked to the side of the joist or girder at or below the middle, as shown in the figure.

Fig. 43 shows the method of anchoring joists to walls where the joists and the walls run parallel. The anchor, let into the floor joists as shown at *a*, is provided with a washer *b*, and should be long enough to run over two or three joists, and 8 inches into the wall in order to give proper stiffness. The floor joists are shown at *c*, and the 12-inch brick wall at *d*.

98. Fig. 44 illustrates common forms of ties for anchoring **I** beams, channels, etc. to brick walls. Ordinary wall anchors are shown in (a), (b), (c), and (d), while in (e) is represented a tie-rod anchor running through the wall, to be used when the beam is run parallel to the wall.

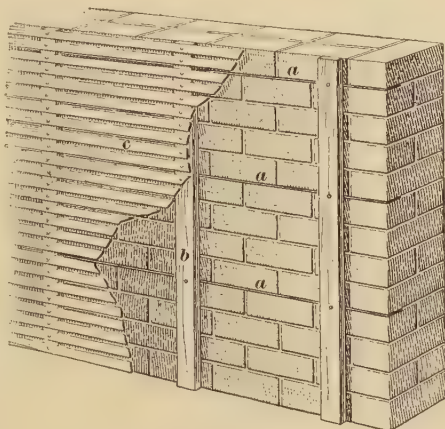


FIG. 45

Steel beams are generally supported on steel templets that are set in the wall. These templets, shown at *a* in (a) and (b), should be made large enough to distribute the load over a sufficient surface of brickwork so that the brickwork will not be crushed under the load.

99. Attaching Furring, Grounds, Etc. to Brick

Walls.—In most buildings it is necessary to attach wood or metal furrings, grounds, bucks, etc., to brickwork, and there are various methods used for this purpose.

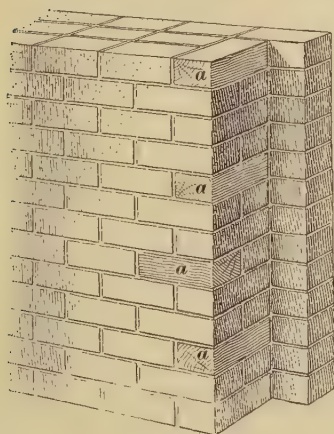


FIG. 46

Where the interior of the wall is to be furred with wood furring to receive lathing and plastering, common lath are laid between the bricks every few joints as shown at *a* in Fig. 45. They are held in place firmly by the brick and afford nailing for the furring. Wood should not be in-

serted in chimney walls and breasts, but metal furring and lath should be used, the furring being attached to wire loops

or other devices built in the brickwork. Nails should never be driven into a chimney wall less than 8 inches thick, as they are liable to break out the mortar on the inside and render the chimney defective.

100. In special places, such as at a door jamb, it is necessary to provide specially good nailing, and **wood bricks** are

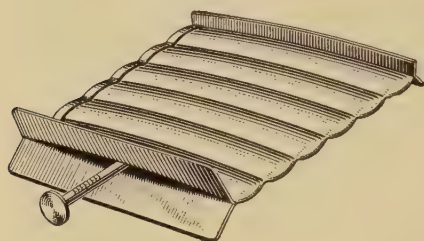


FIG. 47

built into the wall as shown at *a* in Fig. 46. These are blocks of wood of the same size as a brick and are built in the wall in the same manner as ordinary brick.

101. A patented device known as a wall plug is shown in Fig. 47. This consists of a bent corrugated piece of metal that is built into the joints of the brickwork and into which a nail can be driven securely.

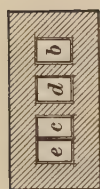
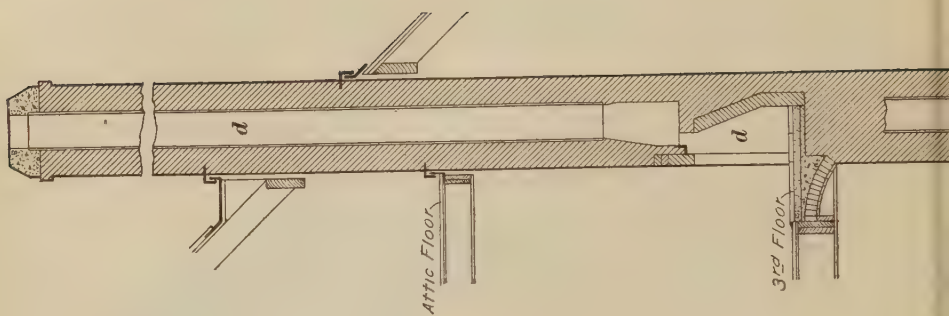
102. Devices for attaching work to brick walls, but which are not built in the walls, will be discussed elsewhere, as they do not properly come under the subject of brickwork.

CHIMNEYS AND FIREPLACES

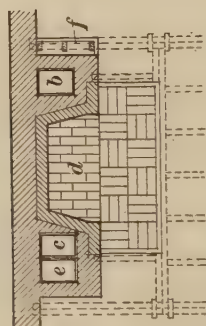
CHIMNEYS

103. Design.—The correct location, area, and height of chimneys should be carefully considered in designing a building. To make a chimney draw well, a separate flue should be provided extending from each fireplace, stove, or furnace to the top of the chimney. It is not considered good practice to use one flue for two or more of these features, although it is sometimes done with satisfactory results.

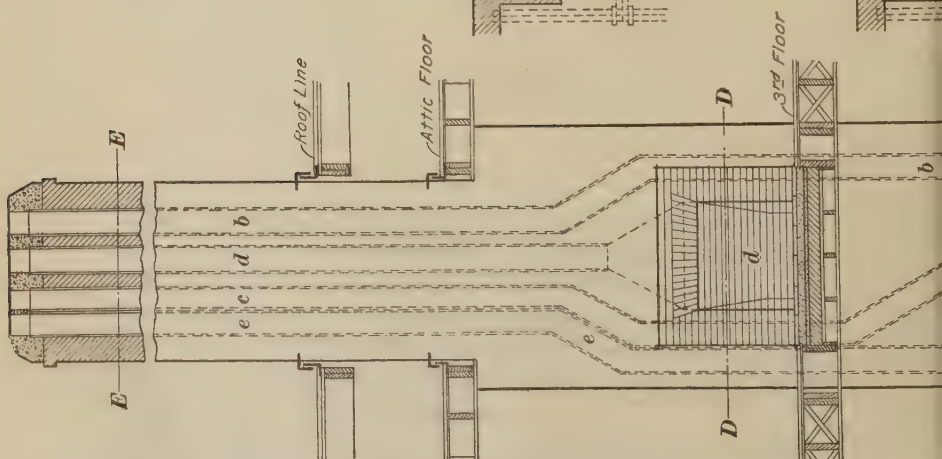
104. Construction of Chimneys.—Chimneys are generally constructed of brick and contain fireplaces, spaces for



Section E.E.



Section D.D.



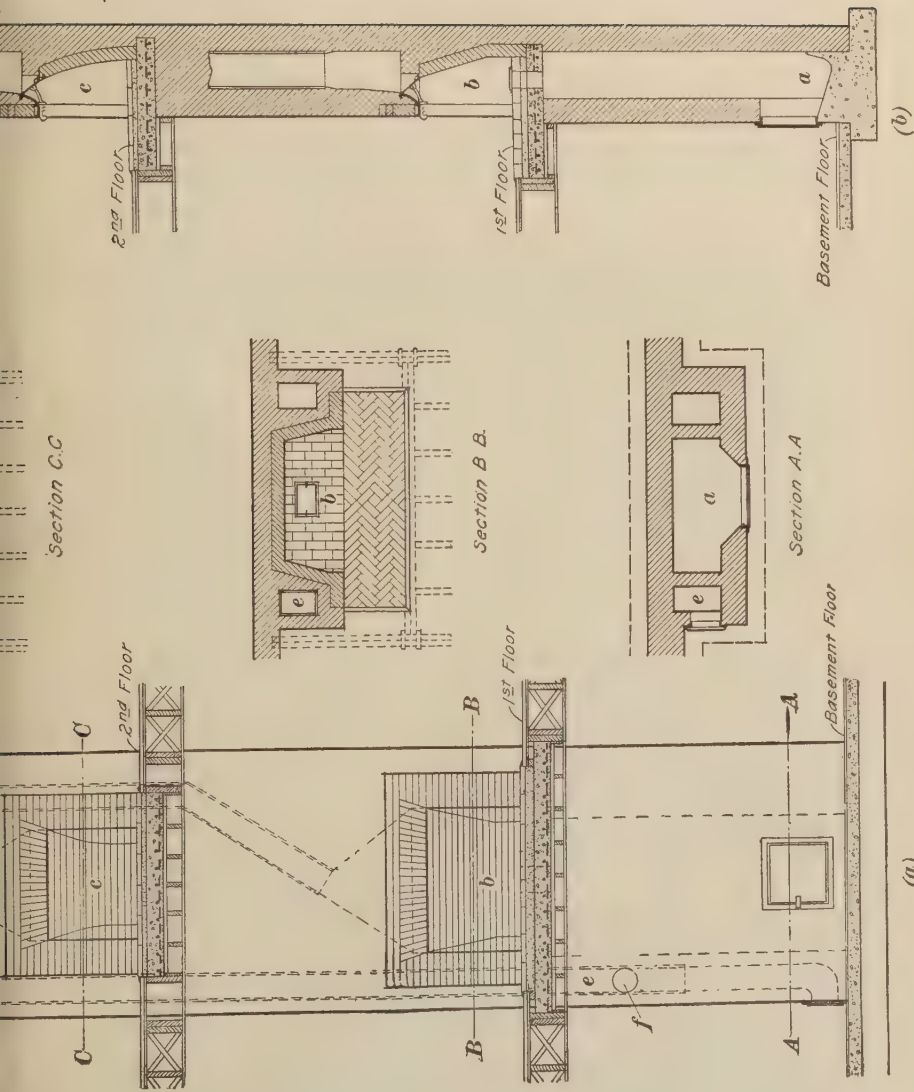


FIG. 48

(a)

ILT 31C \$ 7

ranges, ash-pits, flues, etc. These features are combined so as to form a compact and economical structure which is sometimes very complicated.

An example of the arrangement of parts in a chimney is shown in Fig. 48, which is a chimney built in with the side wall of a brick building. In (*a*) is shown a front elevation of the chimney; in (*b*), a section through the center lines of the fireplaces. Between these views are shown horizontal sections or plans of the chimney at each floor, in the cellar, and above the roof.

In the upper stories are shown the fireplaces *b*, *c*, and *d* and in the basement or cellar the ash-pit *a*. This ash-pit receives the ashes from the fireplace *b* through the ash door shown in the section (*b*). The ash-pit is provided with a cast-iron door through which the ashes are removed. A flue *e*, shown in dotted lines in (*a*), reaches from the basement floor to the top of the chimney. At the bottom of this flue, near the floor on the side of the chimney, is shown an iron door for cleaning out this flue. At *f* is an opening into the flue *e* designed to receive a smoke pipe from a heater or furnace. The flue *e* runs up past the fireplaces *b*, *c*, and *d* and is then bent toward the center of the chimney.

105. Flues.—The flues from the fireplaces are similarly shown by dotted lines extending from points above the tops of the fireplaces to the top of the chimney. The brick partitions between chimney flues are called **withes**. As shown, the flue from any fireplace must pass on the side of the fireplace above, but the flues are deflected above the last fireplace and brought together so as to make the chimney, where it extends above the roof, as compact as possible.

The bends in the flues should be as gradual as possible so as not to check the flow of smoke and gases up the flue. The double dotted lines indicate that the flues are lined with terracotta linings. These flue linings should be carefully cut to miter or fit together at the bends so as to form a smooth channel. Flues having slight bends are considered preferable to perfectly straight flues, as the bends prevent rain and sleet from

falling into the fireplace, and also tend to check the downward passage of currents of cold air. The smoke flues are sometimes formed in brickwork without linings, in which case the walls of the chimney should be 8 inches in thickness. The interiors of such flues should never be plastered, as the plastering is disintegrated by the heat and will fall off. When flue linings are used the chimney walls need be only 4 inches in thickness. Where linings are not used a 4-inch brick partition, or withe, should be built between the flues. The building codes of many cities require that all chimney flues be lined with fireproof material such as terra-cotta flue linings.

106. The advantages of using terra-cotta flue linings are several. In the first place, they are made in 24-inch lengths, which makes few joints. The inside surfaces of the linings are smooth and thus facilitate the flow of smoke and gases up the chimney. In unlined brick flues there is always a risk that the joints between the bricks may not be properly filled with mortar and that sparks will find their way through the crevices and start a fire in adjacent wooden parts of the building. When the flues are lined, however, this danger is reduced to a minimum.

107. Sizes of Flues.—The sizes of brick flues are generally made in accordance with the sizes of bricks used on the work. These flues are about 4, 8, 12, 16, and 20 inches in either direction. Terra-cotta flue linings are made in circular, square, or rectangular shapes. The square and rectangular flue linings are made to fit in with the brickwork.

108. In Table II is given a list of the customary sizes of terra-cotta flue linings. The dimensions of the square and rectangular flues are the outside dimensions. The thickness of the shell, which is from $\frac{3}{4}$ inch to 1 inch, is deducted in estimating the net area of the flue. The inside diameters of the circular pipes are given and the areas are easily calculated from them. While $4\frac{1}{2}$ -inch flue linings are listed in Table II, this dimension in a smoke flue is too small to be effective and should not be used except where unavoidable or in fireplaces where only gas is burned, which permits of the use of a small flue.

109. Proportions of Flues to Fireplaces.—A good proportion for flues for fireplaces in which wood or bituminous coal is to be burned is to make the sectional area of the flue equal to one-tenth of the area of the fireplace opening if the flue is rectangular, and one-twelfth, if the flue is circular. Thus, for a fireplace that is 30 inches wide by 30 inches high and whose area is 900 square inches, the flue area for the rectangular form of flue would be 90 square inches, which will

TABLE II
DIMENSIONS AND EFFECTIVE AREAS OF FLUE LININGS

Rectangular Flues		Circular Flues	
Outside Size Inches	Approximate Inside Area Square Inches	Inside Diameter Inches	Inside Area Square Inches
$4\frac{1}{2} \times 8\frac{1}{2}$	16.25	6	28.27
$4\frac{1}{2} \times 13$	27.50	7	38.48
$4\frac{1}{2} \times 18$	40.00	8	50.27
$8\frac{1}{2} \times 8\frac{1}{2}$	42.25	9	63.62
$8\frac{1}{2} \times 13$	71.50	10	78.54
$8\frac{1}{2} \times 18$	104.00	12	113.10
13×13	121.00	15	176.72
13×18	176.00	18	254.47
18×18	256.00	20	314.16
		24	452.39

require an 8"×12" brick flue. If flue linings are used, an 8½"×18" or a 13"×13" flue will be required. The area of a circular flue lining would be $\frac{1}{12} \times 900 = 75$ square inches. The nearest stock size of lining is 10 inches in diameter, which, having an area of 78.54 square inches, would be satisfactory.

If anthracite coal is to be burned, the flue area may be made one-fifteenth of the area of the fireplace opening for a rectangular flue, and one-eighteenth for the circular form. Thus, for a fireplace with an area of 900 square inches a rectangular

flue with an area of $\frac{1}{15} \times 900 = 60$ square inches will be required. According to Table II, an $8\frac{1}{2}'' \times 13''$ flue must be used for this area. A round flue of $\frac{1}{18} \times 900 = 50$ square inches, or 8 inches in diameter, will be needed.

110. Chimney Caps.—The portion of the chimney projecting above the roof should be laid up in strong cement mortar so as to prevent its disintegration, and should be covered with a protecting cap of stone or concrete. This cap may be pierced with holes to match the flues as shown in (a) in Fig. 49,

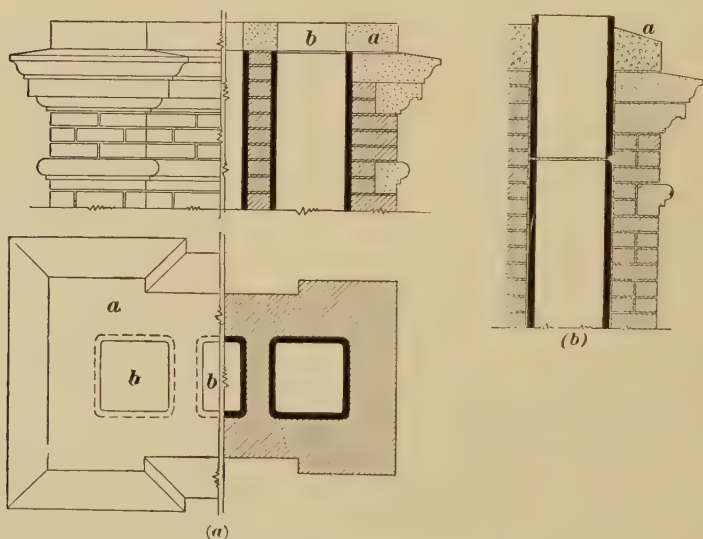


FIG. 49

in which *a* is the capstone of the chimney and *b* the holes cut through flush with the inner edge of the flue lining and covering the joints between the brickwork and the linings. This prevents water from entering the joints of the brickwork, which would soon cause disintegration of the mortar, loosening of the bricks, and discoloration on the exterior of the chimney.

Another method frequently followed is to project the flue lining above the masonry, as in (b), and to build on a concrete or cement cap, *a*. This prevents swirling air-currents, with perhaps accompanying snow flakes, from descending the flue.

It also tends to decrease the erosion under the cap due to water entering the exposed joints in the brickwork. Concrete, however, is more apt to deteriorate under heat, cold and moisture than stone, and thus is likely to prove less durable.

A chimney cap that is not perforated is shown at *a* in Fig. 50. This cap is supported at the four corners by small brick piers between which the smoke passes through the spaces *b*. Such a cap prevents rain and sleet from falling into the chimney.

111. Chimney Pots.—Instead of flat caps, **chimney pots** made of terra cotta are sometimes used. These pots form

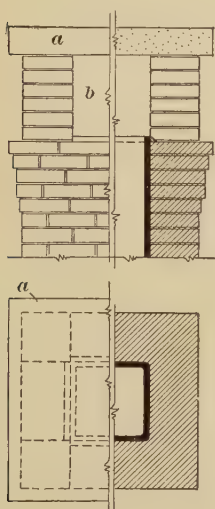


FIG. 50

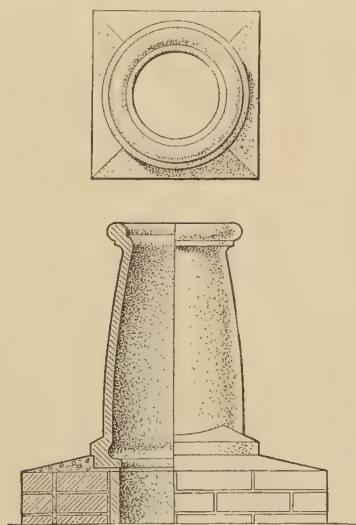


FIG. 51

a picturesque and ornamental finish to a chimney. They are made in many different forms, which are kept in stock by dealers. Examples of terra-cotta chimney pots are given in Figs. 51, 52, and 53 showing half exterior views and sections. The sections show the manner in which the pots are set, so as to cover the flue lining in the chimney. One pot is required for each flue. A strong cement mortar is used in setting the pots and is graded away from the pots to the outside of the chimney so as to form a wash. The design in Fig. 51 is a simple one

with graceful lines and is round or circular in plan. The design in Fig. 52 is more elaborate and is octagonal in plan.

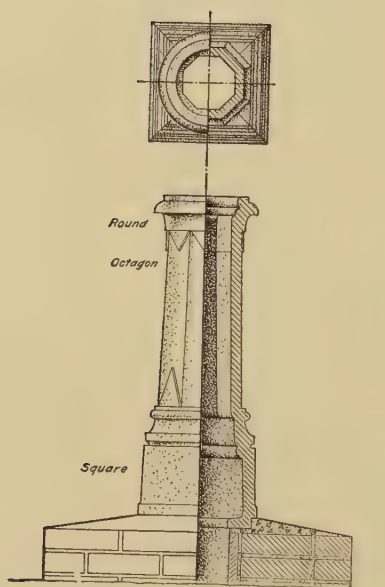


FIG. 52

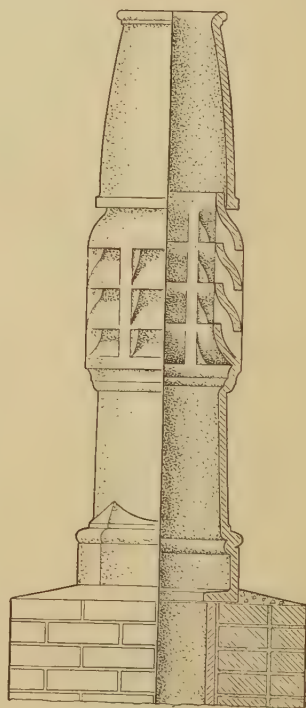


FIG. 53

Fig. 53 is a larger and more elaborate design than the others, with outlets for the smoke in the sides as well as the top.

FIREPLACES

112. Construction of Fireplaces.—The general construction of a fireplace is shown in Fig. 54. The projection of the chimney into the room to enclose the fireplace is called the *chimney breast*. The height of an ordinary fireplace opening should be about 2 feet 6 inches or 2 feet 8 inches above the finished floor, its depth from 16 inches to 24 inches, and its width from 2 feet to 5 feet. If the height of the opening is

made more than 2 feet 8 inches the flue should be made of such a size that the upward draft will be strong enough to prevent smoke coming out into the room.

While a good fireplace can be made that is rectangular in plan, it is better to slope the sides and back as shown in the

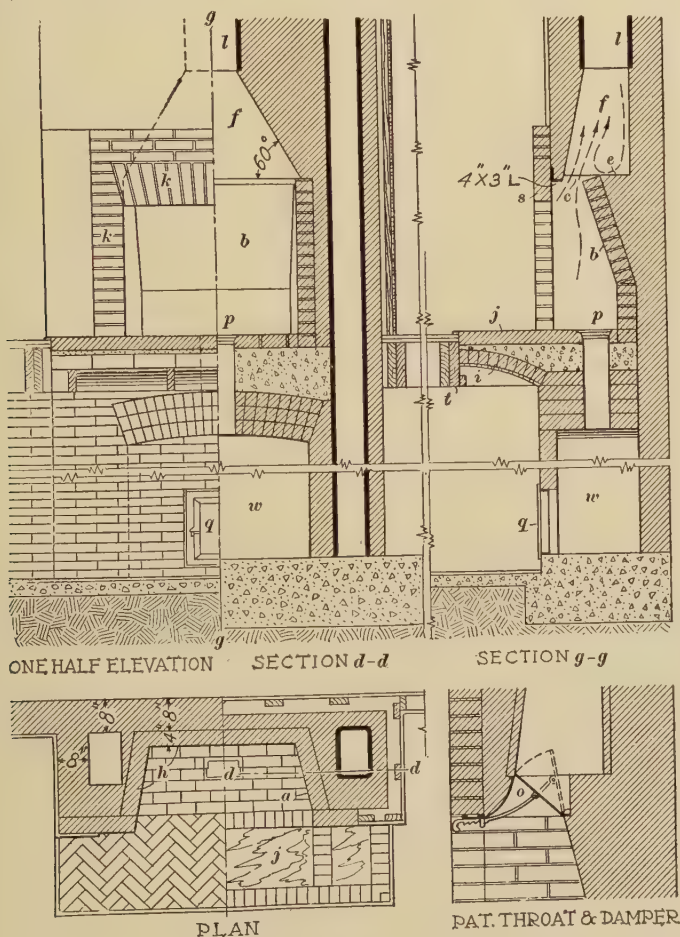


FIG. 54

figure, as these sloping surfaces throw the heat into the room. A slope of about 3 inches in 1 foot, as shown in the plan, is satisfactory.

The *back b* of the fireplace should slope forward and form the *throat c*, which should be from $2\frac{1}{2}$ inches to 4 inches in depth and the full width of the fireplace opening. The total area of the throat should be not less than the area of the flue lining. The throat should be, at least, 2 inches or 3 inches above the top of the opening of the fireplace as shown at *s* and as near the front of the fireplace as possible. Backs may also be curved, as illustrated in fireplace *c* in Fig. 48.

A *smoke shelf e*, Fig. 54, is an important feature. It prevents the air from rushing down the flue when a fire is started and forcing smoke into the room. The *smoke chamber f* is formed by drawing the brickwork together at an angle of 60° on the sides until it is reduced to the dimensions of the flue lining. The bricks should be clipped so as to present as smooth a surface as possible and not a series of offsets. The lining *l* is then started, being supported by the brickwork, as shown. The hearth shown at *j* is extended in front of the fireplace so as to catch embers that may fall out of the fire. It is supported on a trimmer arch *i*, consisting of a single rowlock arch about 20 inches wide springing from the chimney to the header *t*. This arch is laid upon a wooden center which is sometimes left in place, but is liable to be set on fire by a very hot fire on the hearth above. A better practice is to remove the centering of the trimmer arch and cover the space with metal furring and metal lath, to which the plastering may be applied. Upon the trimmer arch, the hearth is built up of cement or concrete and is finished in tile, marble, or brick. The hearth should extend at least 12 inches on each side of the fireplace opening. In Fig. 48 is shown another design for a hearth in fireplaces *b* and *c*. This design is built of reinforced concrete which is cast partly upon wooden forms and partly upon the masonry of the chimney. Iron rods are placed as shown and the concrete is poured so as to surround them. This construction forms a solid slab upon which the finish of the hearth is placed. This finish may consist of brick, tile, or cement.

113. Finish of Fireplaces.—The fireplace shown in Fig. 54 is lined with firebrick or good hard-burned brick. A

loose grate in which coal may be burned is sometimes placed in a brick opening. In some cases ornamental sheet-iron or cast-iron linings are placed in the fireplace as shown in Fig. 55.



FIG. 55

In this case a hard-burned common brick or else firebrick may be used in constructing the fireplace, as the lining will cover this work.

114. Patent Throats and Dampers.—As it is desirable at times to reduce the draft in a fireplace, a damper should be provided that will permit of partially or entirely closing the throat of the fireplace. There are several patent dampers on the market that are designed to be built in at the top of the

fireplace for this purpose. An example of such a damper is shown in Fig. 54, which shows by solid lines the position of the damper when closed and the position when open by dotted lines. Above this damper a patent throat is sometimes used and is made of concrete or of terra cotta similar to the flue linings. This throat forms the sloping smoke chamber that would otherwise be made in brickwork.

115. Ash Doors and Pits.—When possible, it is very desirable to have an ash door in the hearth under a grate through which ashes may be dropped into a suitable space in the cellar portion of the chimney. This arrangement is shown in Fig. 54, where the ash door is at *p* and the pit at *w*. A door *q* is provided at the bottom of the ash-pit through which the ashes may be removed from time to time. A similar arrangement is illustrated in Fig. 48.

FACE AND ORNAMENTAL BRICKWORK

INTRODUCTION

1. Use of Brick.—Brick is one of the most useful of all building materials as well as one with which highly artistic effects can be obtained. Its use for utilitarian purposes, such as building walls and piers, will be considered in the Section entitled *Common Brickwork*. Its possibilities as a decorative material will be discussed in the following pages.

2. Brick as a Decorative Material.—Brick can be used ornamentally or decoratively in two different ways. One way is by laying it so as to form patterns on the surface of walls and piers by the use of different sizes, colors, and surface textures, also by using mortar of varying color and texture and by using mortar joints of different thicknesses. This method of producing attractive and artistic effects in brickwork will be discussed under the heading of Face Brickwork. An example of artistic face brickwork is shown in Fig. 1.

3. Brick can also be used as relief ornament in the form of string-courses, cornices, brackets, etc., which project beyond the face of the wall, as shown in Figs. 2, 6, and 7. Brickwork of this description will be referred to as Ornamental Brickwork.

4. Combinations of Face and Ornamental Brickwork.—Combinations of these methods of using brick have been employed with charming results, as shown in Fig. 2. This



FIG. 1

building is a dove-cote, or pigeon coop, at the Manoir D'Angot in France and was built in the 16th century. This example illustrates the use of *ornamental brickwork* in the projecting



FIG. 2

cornice as well as of *face brickwork* in the patterned surface of the wall. In this building, small blocks of stone have been used in connection with brick to produce contrast in texture and color in the patterns.

5. At the present day architects and builders have at their disposal a wealth of material in the form of bricks of different sizes, shapes, colors, and textures, as well as tiles of all colors, which afford excellent opportunities for designing walls of artistic excellence. An example of such a wall is given in Fig. 1.

DEFINITIONS

6. As there are a number of terms used in connection with brickwork that will be used frequently in connection with the following descriptions, definitions of these terms are here given.

In referring to the individual bricks, the different faces of the brick will be referred to as follows and as illustrated in Fig. 3.

The **top** is the upper large surface.

The **bottom** is the lower large surface.

The **face** is the long narrow side or edge that shows in the face of the wall.

The **back** is the long narrow side or edge opposite the face.

The **heads** are the small ends of the brick.

A **unit** is one brick or piece of brick used in a pattern or a bond.

A **stretcher** is a brick that is laid on its bottom with its face showing in the face of the wall, or a brick whose length extends in the direction of the wall, as shown in Fig. 4 at *a*.

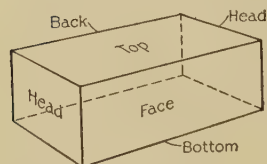


FIG. 3

A **header** is a brick laid on its bottom with the head showing in the face of the wall, as at *b*.

A **bull header** is a brick laid on its face or back and showing a head in the face of the wall, as at *c*.

A **course** of brick is one horizontal row of bricks, as at *e*.

A **stretcher course** is one row of *stretchers*, as at *d*.

A **header course** is one row of *headers*, as at *e*.

A **rowlock**, or **rollock**, **course**, is a row of *rowlocks*, or *bull headers*, as shown at *f*.

A **soldier course** is a row of bricks with the faces laid vertically, as shown at *g*.

A **string-course** is a horizontal course continued across the face of a building. It generally projects and may be flat, molded, or carved.

A **herring-bone pattern**, shown at *h*, consists of bricks laid diagonally in opposite directions.

Bond is the arrangement of the bricks in the wall by which the wall is tied, or bonded, together. This bonding is accomplished by lapping each brick over two or more bricks below it.

Face bond is a bond, or pattern, which shows on the face of the wall but is not generally carried through the entire thick-

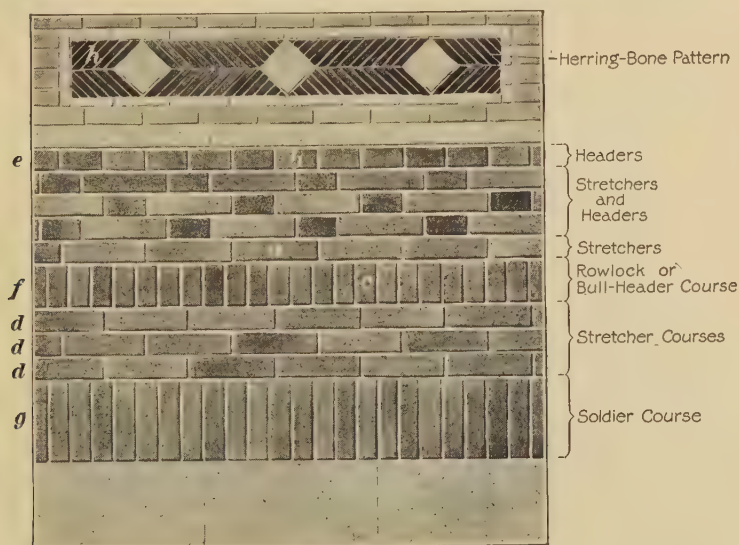


FIG. 4

ness of the wall. The substantial body of the wall may be built in some strong bond that is economical to build, while the face of the wall may be finished in a more elaborate and totally different bond. This ornamental facing of brick must be securely fastened to the wall back of it, upon which it depends for support. The substantial wall to which the facing is attached, or bonded, is often referred to as the **backing**.

The **brick field** is the brick surface of the wall.

Breaking joints is the arrangement of the joints of the brickwork so that the vertical joints in one course shall not come directly above the vertical joints in the course below.

A **blind joint** is a joint between two bricks that is made as thin and inconspicuous as possible so as scarcely to be noticeable.

BRIEF HISTORY OF BRICKWORK

7. Brick architecture has naturally developed in countries or parts of countries where there was an abundance of clay from which bricks could be made, and where there was a scarcity of wood and stone. Thus, in ancient Babylonia, most of the building of importance was done with clay products such as brick. Some of these bricks were merely dried in the sun,

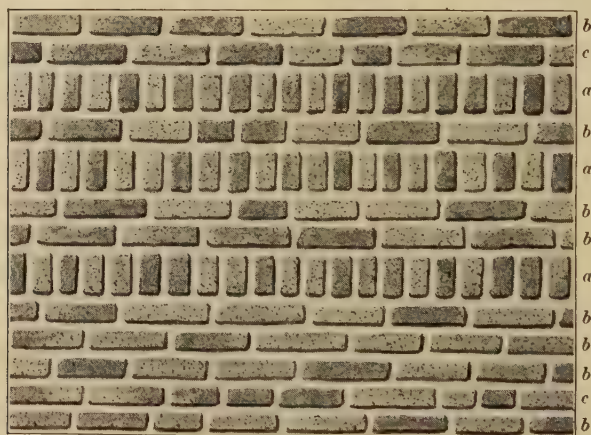


FIG. 5

and are known as *sun-dried* bricks, while some of them were baked in kilns as is done at the present day. A few examples of typical brickwork of various countries, both ancient and modern, will now be described and shown.

8. **Egypt.**—Brickwork found in ancient Egyptian tombs is illustrated in Fig. 5, which shows an example from the tomb

of Mersekha, built about the year 2900 B. C. This brickwork shows a pattern, or bond, which consists of rows of headers *a* separated by rows of stretchers *b*. The headers are bull

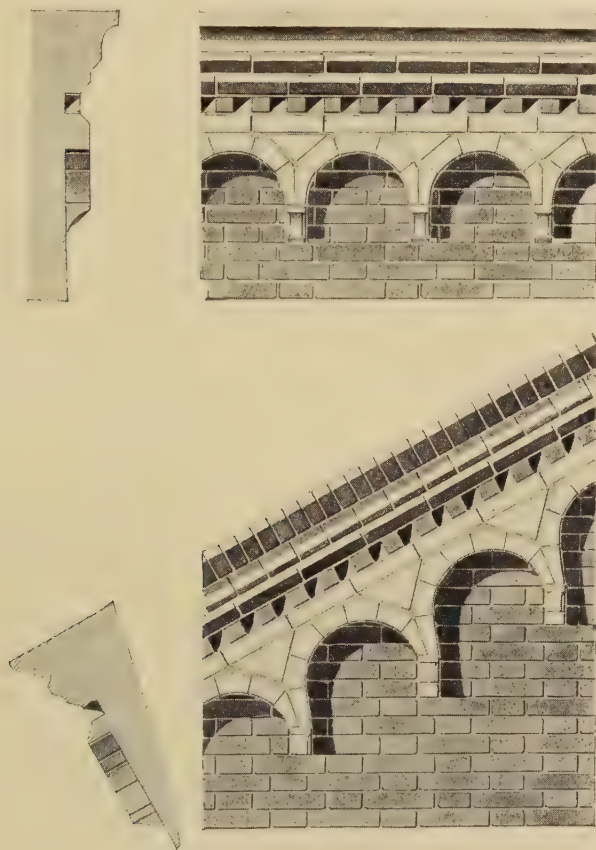


FIG. 6

headers. The bricks are roughly molded and irregular in size. Headers are introduced occasionally in the rows of stretchers, as shown at *c*. A number of the well-known Egyptian pyramids were built of brick.

9. Ancient Rome.—The Romans used brick extensively. The bricks themselves were always flat, varying from $\frac{1}{2}$ inch

to 2 inches in thickness. In the Baths of Titus, erected about 80 A. D., the bricks were about 18 inches by 6 inches by 2 inches in size. Bricks found in remains of Roman structures in England are dark red and light red in color, these colors being used together in the walls. These bricks were laid with wide mortar

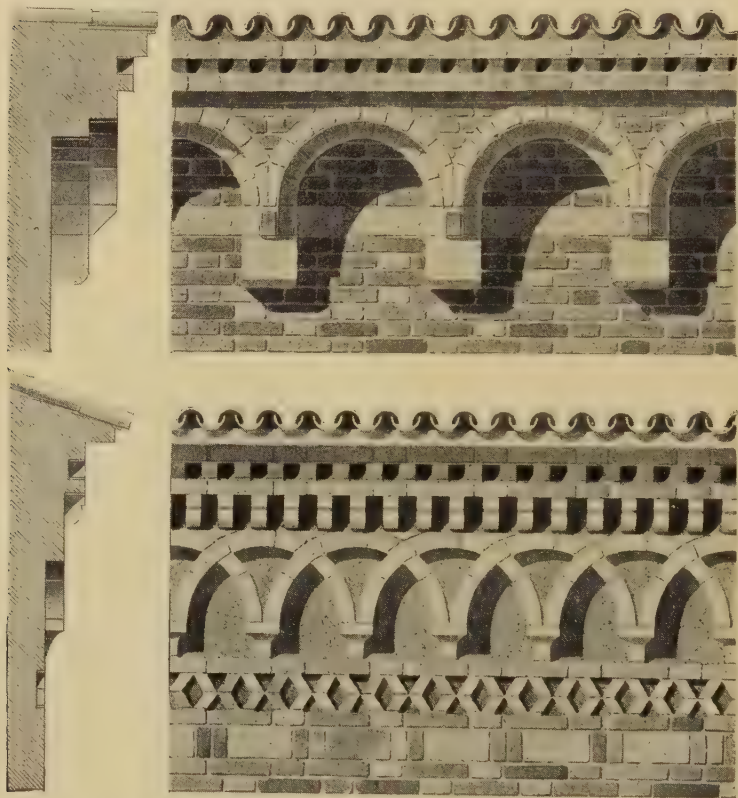


FIG. 7

joints, and the mortar used was generally composed of lime mixed with broken tiles, sand, and gravel more or less coarse in size.

Excellent examples of Roman brickwork have been found in England. At Caster, an ancient Roman camp, a fine example of herring-bone masonry was found. Another example exists in St. Botolph's Priory near Colchester.



FIG. 8

10. Italy. — In Italy during the Middle Ages, especially in the cities of the North, brick architecture reached great perfection in its application to churches and civic buildings. Brick was used in connection with terra cotta and stone, and ornamental brickwork of the highest artistic character was used in the cornices of Italian buildings. Examples of these cornices are shown in Figs. 6 and 7. Other examples of Italian brickwork are: Baptistry of St. Stefano, 4th century; St. Agata in Ravenna, 5th century; Cathedral, Cremona, 12th century; Broletto (Town Hall), Brescia, 13th century; San Pietro Ciel D'Oro, Pavia, 13th–15th centuries.

11. Persia. — It was in the 16th century that Persian brickwork reached that degree of excel-

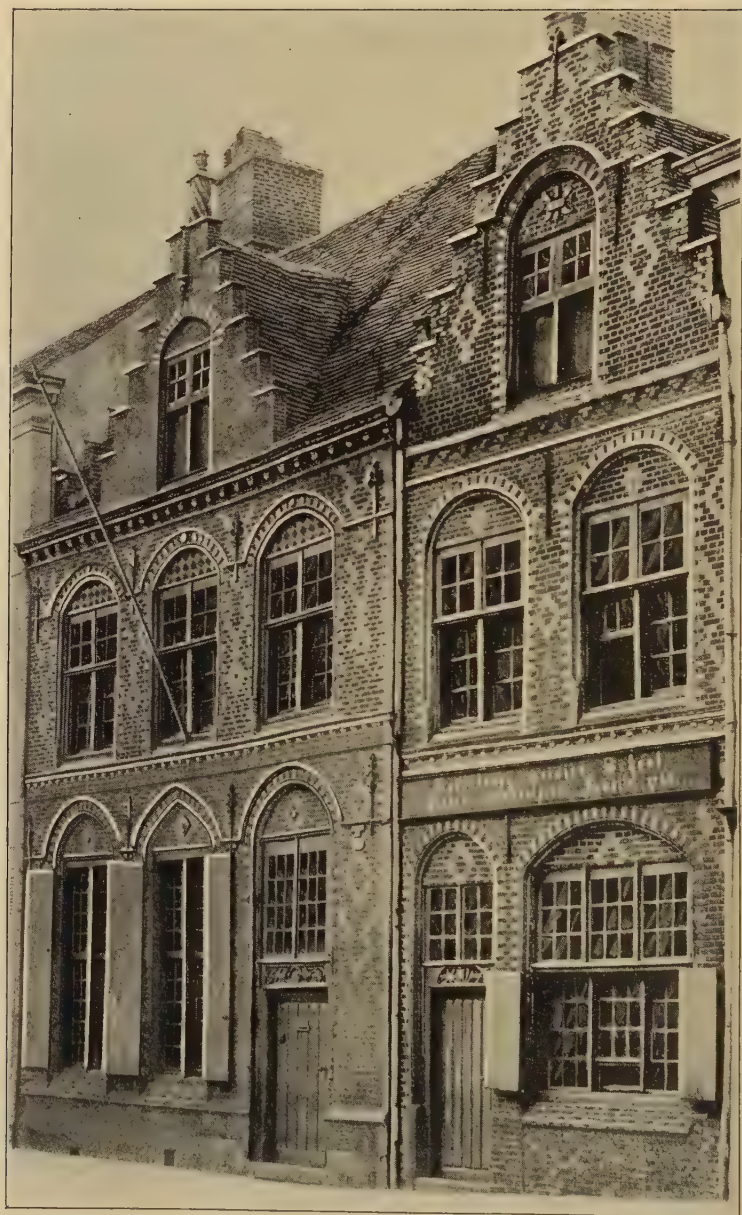


FIG. 9

lency which characterizes so many Persian mosques and mausoleums as masterpieces of the brickbuilder's art and ingenuity. Notwithstanding that brick architecture had been practiced in Persia from the 7th century, it was in the early part of the 16th century that buildings were built that are notable for their workmanship, color, and design. At Bostam, Ispahan, Tebriz, and Ardebil, the mosques and minarets are monuments of the possibilities of brick as a means of decoration. An example of this work is given in Fig. 8. The building shown is a minaret, or prayer tower, connected with the mosque of Tschihil Sutun in Damgan, Persia, and was built in the 16th century.

12. Netherlands.—During the 14th and 15th centuries, the brickbuilders of the Netherlands were not only erecting their homes and public buildings of brick, but were also instructing their neighbors, the English, in the use of brickwork. Their buildings with the quaint *stepped* gables possess great individuality and charm. In Fig. 9 are shown two excellent buildings which were built in Ypres, Belgium. These buildings show the delicacy and refinement with which brick was employed, and also illustrate the formation of patterns by the use of brick of different colors. Molded brick have also been used around the windows and in the string-courses.

Notable examples of brickwork are given in the following list of buildings:

Church of St. Martins, Ypres, Belgium....	14th century
City Gates, Haarlem, Holland.....	15th century
Tournal House, Holland.....	15th century
St. Jean Hospital, Hoorn, Holland.....	16th century
Convent des Celestines, Tournal, Holland..	16th century

13. England.—The earliest brick building existing in England is Little Wenham Hall in Lincolnshire, which was built in 1260. By the year 1300, brickwork was in general use in England. The great manor houses of England were erected in the 15th and 16th centuries, as shown by the following list of such buildings:

	ERECTED
Hurstmanceaux Castle	1440
Tattershall Castle	1440
Rye House (Hertfordshire)	1440
Lollard's Tower (Lambeth Palace)	1454
Laver Marney Towers	1500
Sutton Place, Guilford	1523
Compton Wynyates	16th century
East Barsham Manor	late 16th century

A portion of the last-mentioned building is shown in Fig. 10.

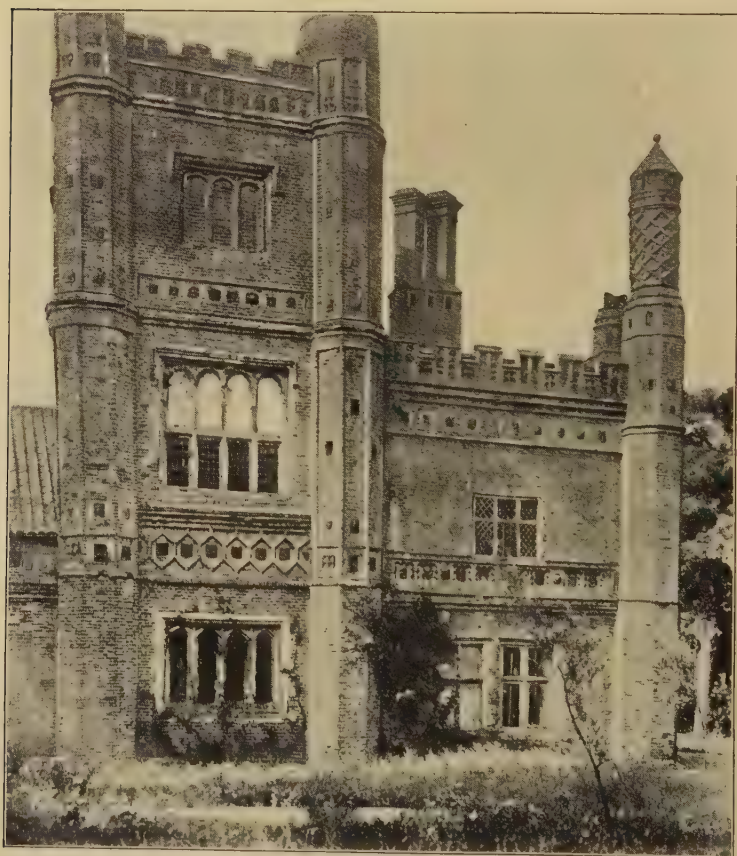


FIG. 10

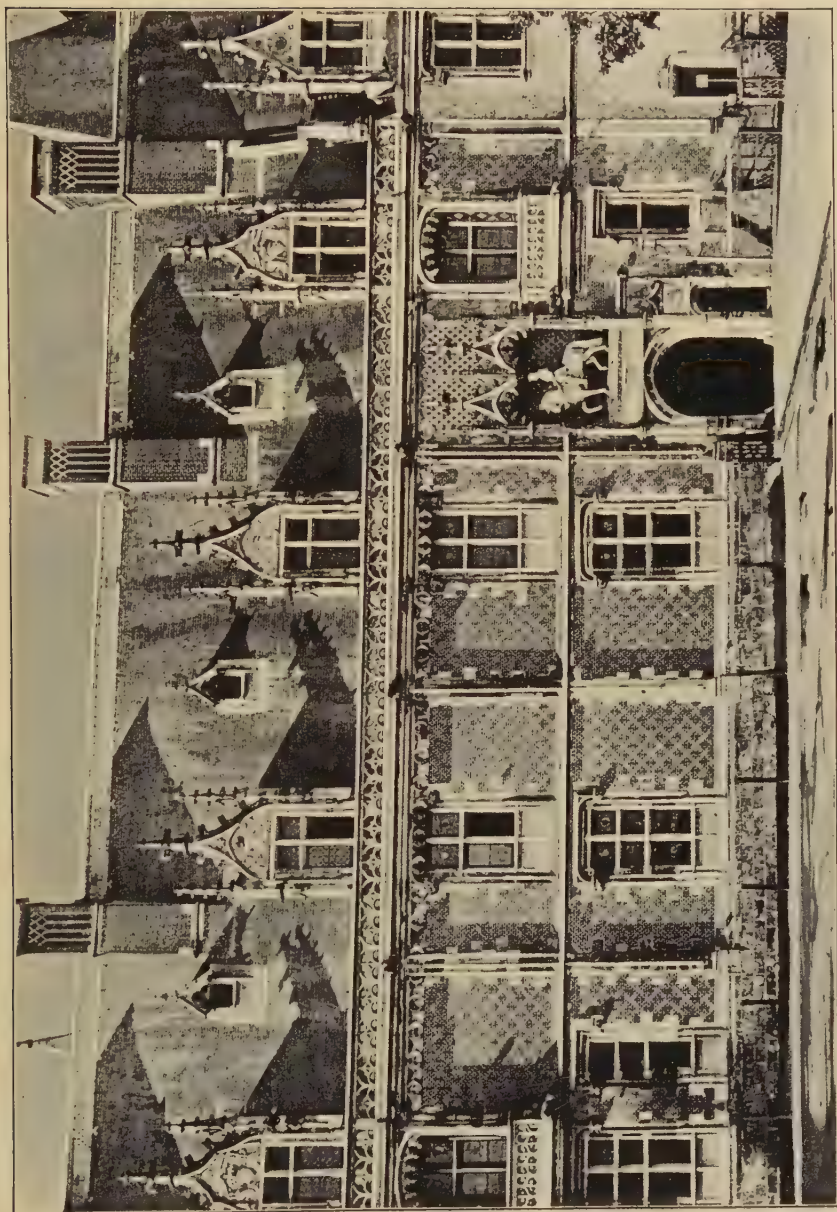


FIG. 11

It was undoubtedly from the Flemish brickbuilders of the Netherlands that the English received the incentive to erect the series of magnificent brick buildings that mark the progress of the history of England.

14. France.—The French people used brick with excellent taste but generally used it for wall treatments in which the brickwork was framed by stone. This treatment is shown in the Louis XIII wing of the Château of Blois illustrated in Fig. 11. The brick surface has a crisscross pattern formed by bricks that are lighter in color than the others. A particularly charming example of French brickwork is shown in Fig. 2, which is the dove-cote at the Manoir D'Angot of the 16th century. Other noteworthy examples of brick architecture are the Château de Martainville of the 15th century at Epreville; the Manoir D'Angot itself, and a pigeon house at Boos.

15. America.—In America, during the Colonial period of its history, our architects and builders developed the Colonial Style of Architecture, which was an offshoot of the Georgian style in England. Brick was imported from England and used with considerable taste in some of the colonial houses in the southern colonies, such as Maryland and Virginia. A decline in architectural taste occurred during a great part of the 19th century but a revival, or renaissance, of good taste has been experienced in recent years which gives promise of most satisfactory results.

Many excellent buildings by such architects as H. H. Richardson, McKim, Mead, and White, and by prominent living architects, are fine examples of brickwork. Designers of the present day have the best possible opportunities for producing fine brickwork, as the manufacturers are now making superior grades of brick which offer great varieties of color, size, and texture as well as durability.

FACE BRICKWORK

DESCRIPTION OF FACE BRICK

BRICK SHAPES AND SIZES

16. The sizes of brick units varied in past ages, according to the locality in which they were produced and the use to which they were to be put, just as they do today. In an ancient Sargonic arch, made about the year 4000 B. C., the bricks measure 12 inches by $2\frac{1}{2}$ inches by 6 inches. Ancient Babylonian brick measured 12 inches by $5\frac{7}{8}$ inches by $2\frac{1}{4}$ inches. Other Babylonian bricks measured $8\frac{5}{8}$ inches by 2 inches by $4\frac{7}{8}$ inches, which are similar in size to bricks made at the present time.

The Roman bricks, as has been stated, were made 18 inches by 6 inches by 2 inches in size.

17. Brick Sizes as Used in the United States.—The standard sizes of brick in the United States are those adopted by the National Brickmakers' Association. For common brick the standard size is $8\frac{1}{4}$ in. $\times$ 4 in. $\times$ $2\frac{1}{4}$ in.; for face brick, $8\frac{3}{8}$ in. $\times$ $4\frac{1}{8}$ in. $\times$ $2\frac{1}{4}$ in.

The brick manufacturers, in making standard brick, only approximate these sizes, as it is impossible to regulate absolutely the amount of shrinkage that will take place between the time the brick is molded and the time it is thoroughly burned. Differences in size are almost invariably found in the same shipment of brick.

It is customary, especially when a fine joint is to be used, to sort out these face brick and place all the bricks of the same size in one pile and those of other sizes in other piles. These different sizes are used in different portions of the wall so that the difference in size is not noticeable.

In some cases the manufacturers make bricks that vary considerably in size from the standard brick. It is therefore advisable, before laying out the drawings for the front of a building that is to be faced with face brick, to obtain by actual measurement the exact size of the bricks that it is desired to use, so as to make the openings in the wall, especially the heights, of sizes that are multiples of the brick size. It is also necessary to know the exact size of the bricks to be used when stone or terra cotta are used in connection with the face brick, to make the heights of the stone or terra-cotta courses equal in height to a given number of brick courses so that the horizontal joints shall coincide.

18. Sizes of Standardized Brick.—There are a number of other standardized sizes of face brick, the names and the approximate sizes of which are given herewith. These sizes are obtained from catalogs of prominent manufacturers and show the variations in sizes which are sold under the same name.

NAMES AND SIZES OF FACE BRICK	
NAMES OF BRICK	APPROXIMATE SIZE INCHES
Real Roman	$18 \times 2 \times 6$
	$17\frac{1}{2} \times 1\frac{1}{2} \times 5\frac{1}{2}$
	$18 \times 1\frac{1}{2} \times 6$
Norman	$12 \times 2\frac{1}{2} \times 4$
	$11\frac{7}{8} \times 2\frac{1}{4} \times 4$
Roman	$12 \times 1\frac{1}{2} \times 4$
	$11\frac{1}{2} \times 1\frac{3}{4} \times 4$
	$11\frac{5}{8} \times 1\frac{5}{8} \times 3\frac{7}{8}$
English	$8\frac{7}{8} \times 2\frac{7}{8} \times 4\frac{3}{8}$
	$7\frac{3}{4} \times 2\frac{1}{2} \times 3\frac{1}{2}$
Standard	$*8\frac{3}{8} \times 2\frac{1}{4} \times 4\frac{1}{8}$
	$8 \times 2\frac{1}{4} \times 3\frac{3}{4}$
	$8\frac{1}{4} \times 2\frac{1}{4} \times 4$
	$8\frac{1}{8} \times 2\frac{3}{8} \times 4$
Split	$8 \times 1\frac{1}{8} \times 4$
Pony	$6 \times 1 \times 2\frac{3}{4}$

* Standard recommended by National Brickmakers' Association.

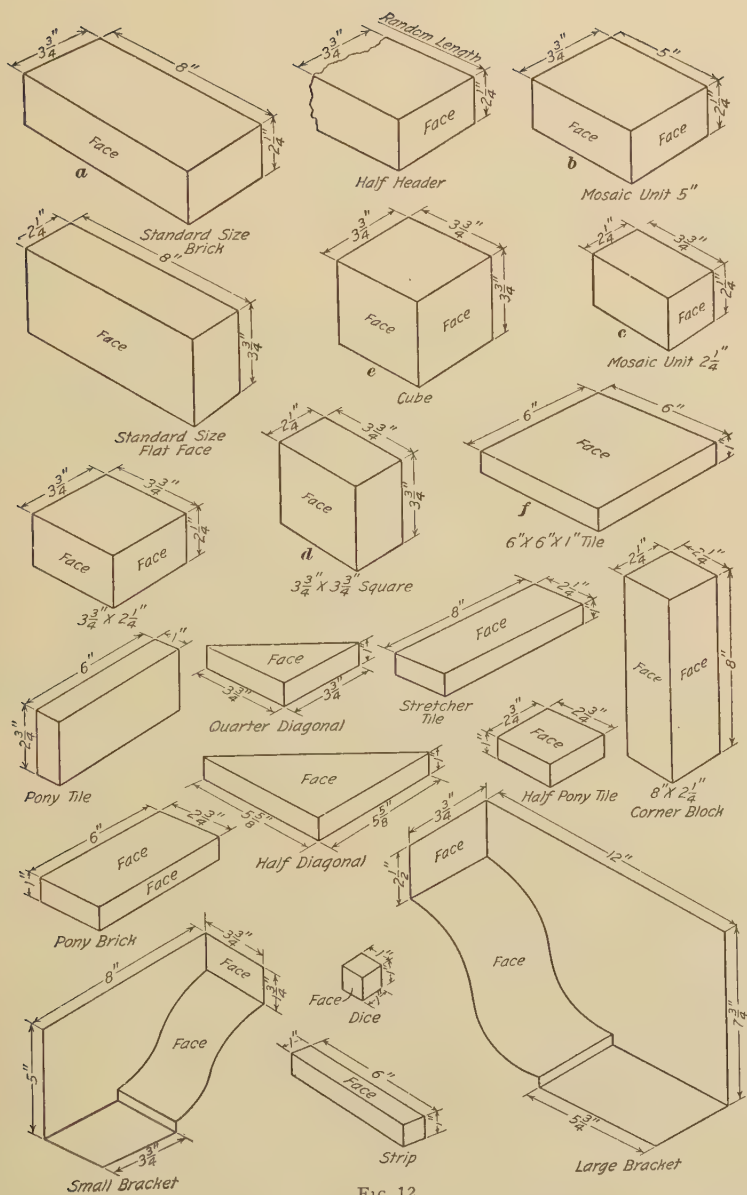


FIG. 12

19. Special Shapes.—Besides these standardized sizes and shapes, there are many special shapes made for use in pattern work. Some of these special shapes are shown in Fig. 12. The sizes of these units are marked in the illustration.

By using the standard-sized brick *a* with the 5-inch unit *b* and the $2\frac{1}{4}$ -inch unit *c*, reproductions of the interesting Persian pattern work such as shown in Fig. 59 can be made.

The square piece *d*, measuring $3\frac{3}{4}$ inches by $3\frac{3}{4}$ inches, is used in turning the corner of a border of bull-headers, or rollocks, as shown at *a* in the panel in Fig. 60. The cube *e*, Fig. 12, is used in turning the projecting corner in a course of rollocks, as shown in the upper corners of the brick flower boxes in Fig. 49. The square brick or tile *f*, Fig. 12, 6 in. $\times$ 6 in. $\times$ 1 in. in size, is used in positions such as shown in the ornamental bands at the tops of the bay windows in Fig. 63.

These special shapes save the mason a great deal of cutting and insure better results in laying out the work; also, they can be used in different colors than those used in the field so as to produce contrasts both in form and color.

20. Tile.—Tile are made of clay similar to that of which face brick are made and have, to a large extent, the same texture and coloring. Enameled and decorated tile are made in numerous shapes, colors, and designs. Patterns made of tiles are often used very effectively in connection with brickwork.

These tile are manufactured of the sizes and surfaces given in the accompanying list:

SIZES AND SURFACES OF TILE	
SIZE. INCHES	SURFACE
12 $\times$ 12 $\times$ 1	Smooth
9 $\times$ 9 $\times$ 1	Smooth
9 $\times$ 6 $\times$ 1	Smooth
8 $\times$ 8 $\times$ 2	Rough and semismooth
6 $\times$ 6 $\times$ 1	Rough, smooth, and semismooth
6 $\times$ $2\frac{3}{4}$ $\times$ 1	Rough and semismooth
4 $\times$ 4 $\times$ 1	Smooth
$2\frac{3}{4}$ $\times$ $2\frac{3}{4}$ $\times$ 1	Rough and semismooth
Half diagonal of a 6" $\times$ 6"	Rough and semismooth
Quarter diagonal of a 6" $\times$ 6" ..	Rough and semismooth

The rough tile has a decidedly rough texture on its face and is used for the floors of porches and terrace walks as well as for wall decoration in connection with rough-textured brick.

BRICK TEXTURES

21. Rough Textures.—A rough texture is commonly produced by mixing a coarse material such as grit or small



FIG. 13

pebbles with the clay, or by cutting the brick with wires when molding it, or by both methods. Fig. 13 shows a brick that is artificially roughened by the introduction of grit and pebbles in the clay. Another example of a brick surface containing pebbles is shown in Fig. 14.



FIG. 14

The surfaces are also roughened by cutting the brick, when molding it, with wires, which drag and tear the soft clay surface, as shown in Figs. 15 and 16. Such brick is called *wire-*

cut brick. When the wire cuts the brick from one end to the other a surface is produced such as is shown in Fig. 15. This

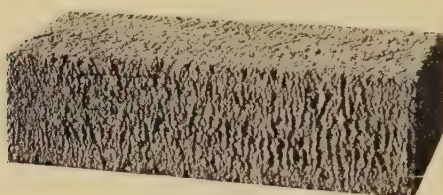


FIG. 15

brick is called an *end-cut* brick. When the wire is drawn from one long edge to the other, a surface like that shown in Fig. 16 is produced. This brick is a *side-cut* brick. The

brick shown in Fig. 13 has been roughened not only by the use of a coarse ingredient in the clay but by a subsequent scratching which produced the vertical marks shown on some of the bricks. Figs. 15 and 16 show a brick with a medium-rough surface.

An example of a rough brick surface, which is due to irregularity in burning during the processes of manufacture, is shown in *clinker* brick which has been cracked and twisted out of shape by the flames in the kiln. This brick, which in the past was generally sent to the rubbish heap, when used with taste and skill forms an artistic wall surface that possesses character and interest. A portion of a wall built of clinker brick is shown in Fig. 17.

22. Smooth Textures.—A smooth brick may be either a *pressed* brick, which is pressed by machinery into an accurate shape with edges absolutely true, or a *wire-cut* brick, which has the largest surfaces cut by the wires of the brick-cutting machine, while the other faces are all perfectly smooth. The edges of a wire-cut smooth brick are not as true as those of a pressed brick and consequently the brick when set has not that mechanical appearance which is characteristic of pressed-brick work. An example of a wall laid up with a smooth-textured brick is shown in Fig. 18.

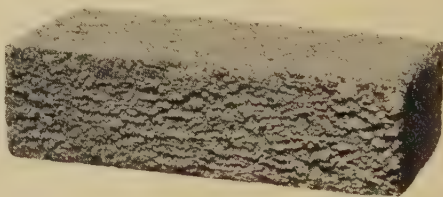


FIG. 16

23. Effect of Texture.—A wall built of bricks that are perfect in shape, absolutely smooth, uniform in color, and laid up with fine even joints, is not only very expensive to build but is very mechanical and inartistic in appearance. This fact is appreciated by architects and designers, and the best modern brickwork is constructed with brick which has more or less roughness of surface and variety of color, and of which the individual bricks are not mechanically perfect in form. With



FIG. 17

brick of this description, properly selected and laid, a wall can be laid that will have character, brilliancy, and interest. Such a wall will not appear hard and set; the color will not be monotonous, and the surface having some texture will give a play of light and shadow that will enliven the appearance of the wall and add brilliancy to the color.

By using some of the rougher-textured brick, new brickwork can be built so as to have a great deal of the charm of ancient work which is so much admired. One of the greatest charms

of the brickwork of the old colonial houses lies in the slightly rough texture and the soft color tones of the brick units.

24. At a distance from the building, the particular texture of the brick units is lost, but the effect of the rougher textures



FIG. 18

is to soften the color of the mass of the brickwork and to do away with the glare which often occurs when the brick units are very smooth in texture.

25. Modern face bricks are generally burned so that they are almost vitrified and will not absorb moisture. Dust from the atmosphere which may lodge on the rough surface of the brick will therefore not be absorbed but will be washed off by rain, thus leaving the color of the brick fresh and clear.

BRICK COLORS

26. Causes and Varieties of Brick Colors.—Bricks in the United States and in Europe are naturally red in color, although, in some parts of the United States, clay is found that produces a yellow-colored brick. The bricks made in China and Japan are generally of a slaty-blue color.



By courtesy of Fiske & Co., Inc.

FIG. 19

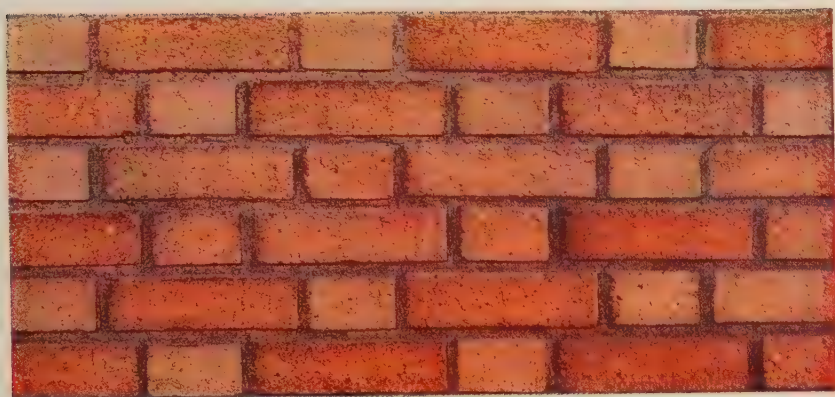
§11 I L T 30C



By courtesy of Fiske & Co., Inc.

FIG. 20

§11 I L T 30C



By courtesy of Fiske & Co., Inc.

FIG. 21

§11 I L T 30C



By courtesy of Hydraulic-Press Brick Co.

FIG. 22

§11 I L T 30C



By courtesy of Hydraulic-Press Brick Co.

FIG. 23

§11 I L T 30C



By courtesy of Hydraulic-Press Brick Co.

FIG. 24

§11 I L T 30C

The presence of iron, magnesia, lime, and other materials in the clay causes the different colorings in the finished brick. Iron in the clay will produce such colors in the brick as light yellow, orange, red, dark blue, and purple, according to the amount of iron present in the clay and the heat at which it is burned. Magnesia gives a brown color; magnesia and iron together, a yellow color; lime and iron together, a drab color.

Different clays contain these elements naturally, and by skillfully mixing selected clays, bricks can be made in a large variety of colors without the use of artificial coloring materials.

The degree of heat at which the bricks are burned has a great effect upon the color of the brick. This is well illustrated in the case of common bricks, which are taken from the old-style kiln with colors varying from a light salmon color to dark blue, according to the amount of heat to which they have been subjected.

The colors in which modern bricks are made are *reds*, varying from light pink to deep red; *buffs*, varying from a light cream color to deep, rich browns; *browns*, which vary from a light brown to a dark brown. There are also blues, purples, greens, and various fancy colors. Examples of some of these colors are shown in the colored illustrations in this Section.

There are generally variations in the face color of the same brick which give an interesting appearance to the individual bricks and also to the brick field. Such brick is shown in Figs. 19, 20, 21, and 22.

The bricks sometimes have iron spots on the surface, as shown in Figs. 23 and 38, or mottles, as shown in Figs. 24 and 29. The surface is sometimes glazed. In short, there is a great variety of texture and color from which the architect may choose, and the success of the choice will depend upon his taste and experience.

27. Judging Effects.—The color or texture of the completed wall can never be correctly judged from the color or texture of a single brick or even from a number of bricks laid up, as the atmosphere and the distance of the wall surface from the eye greatly affect the appearance of the brick. The

best way to judge the effect of a given brick in a building is to see a building built of the same kind of brick, which often can be done.

When a wall of the desired brick cannot be seen, a small sample wall of the chosen brick and mortar is laid up with a certain bond and width of joint. If this sample wall is satisfactory, the combination is adopted and used. If, however, the sample does not meet with approval, other bricks, mortar, joints, and bonds are tried by building small sections of wall until a satisfactory combination is discovered.

In the show rooms of brick dealers, a variety of such sample walls can generally be seen, which will assist the architect and the client in selecting a satisfactory combination.

MOLDED BRICK

28. Ornamental brickwork may be formed of plain brick which is built so as to project and form cornices and

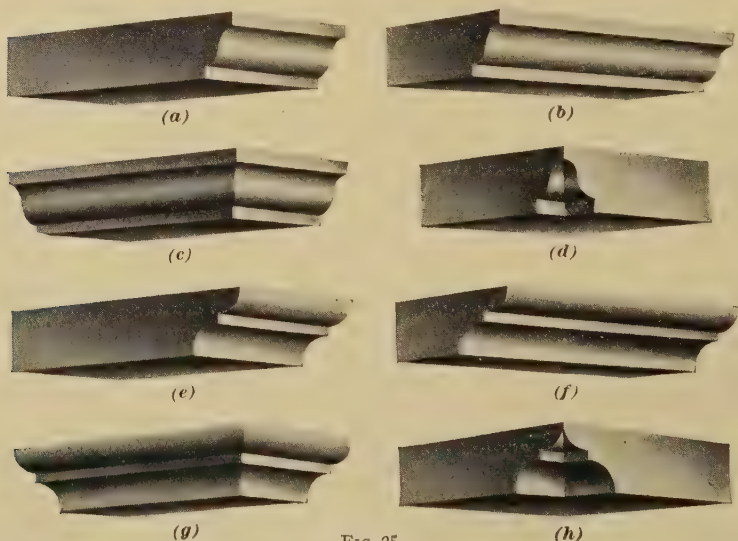


FIG. 25

string-courses in the manner shown in Figs. 2, 6, and 7, or by the use of bricks which are molded into various shapes.

These bricks are made in a large variety of shapes so that many architectural details such as cornices, string-courses, panels, window sills, columns, and pilasters can be made of them.



FIG. 26

The projection of molded brick details must necessarily be small, but several courses of brick can be projected over each other so as to produce a satisfactory total projection in the entire cornice.

The units in which molded brick is made are of such a size that they can readily be laid up with standard face brick and the horizontal joints can be maintained at each course or two.

Some of the more common and useful shapes that are made in molded brick are shown in Fig. 25. In (a) is shown a mold-



FIG. 27

ing known as a *cyma recta*, or crown, molding. These bricks are generally made in four forms to fit them for use in a string-course. A header for this molding is shown in (a); in (b) is a stretcher, in (c) a projecting corner, and in (d) a sunk corner.

In *e*, *f*, *g*, and *h* are shown the four molded bricks required for another form of crown molding, called a *cyma reversa*.

Several profiles of molded brick commonly used are given in Fig. 26. The necessary headers, stretchers, and corners are also made for these moldings.

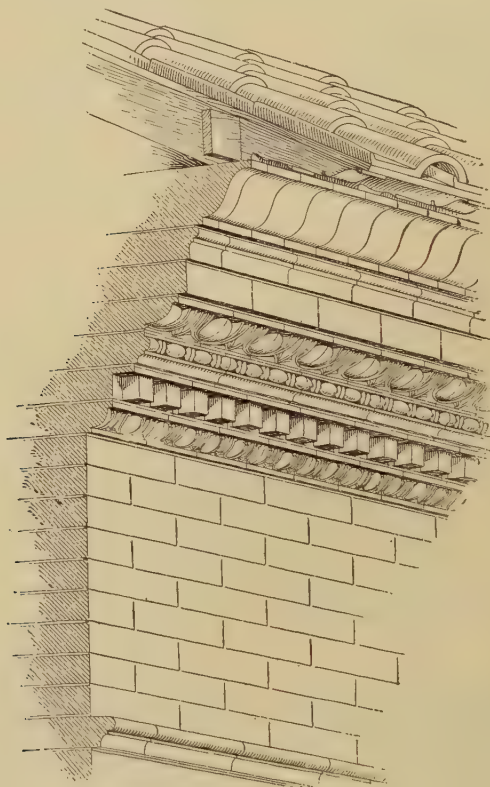
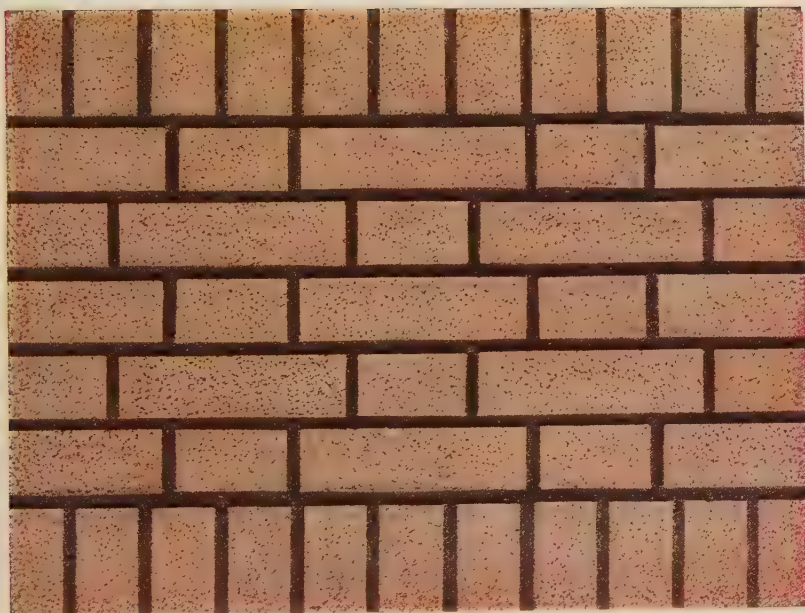


FIG. 28

Ornamental band courses having ornament in relief or projection are shown in Fig. 27.

29. Molded brick are generally made with a smooth finish and are used to the best advantage with smooth-faced brick. They cannot very well be used together with the rough-textured brick that are so popular at the present day.



By courtesy of Hydraulic-Press Brick Co.

FIG. 29

§11 I L T 30C

Molded brick of rough texture are, however, sometimes made of the same color and texture as the brick used in the brick field; an example of such brick is shown in the moldings over the door and window in Fig. 49.

30. Molded Brick Cornice.—A cornice composed of molded brick, together with plain face brick, is shown in Fig. 28. As before stated, the projection of each course must be small, and the total projection cannot be so great as that of a cornice made of stone, terra cotta, or wood.

MORTAR AND MORTAR JOINTS

31. Effect of Mortar and Mortar Joints.—The mortar joint and the mortar are essential factors in the appearance of finished brickwork. In fact they are almost as important as the color and the texture of the brick in their effect upon the appearance of the wall. Where a very thin joint is used, as in Figs. 23 and 24, the principal effect is caused by the *color* of the mortar.

The color of the mortar may be in contrast with the color of the brick, as in Fig. 29, thus forming a network of contrasting color over the entire surface of the wall, or it may be similar in color to the brick itself, as in Fig. 24, in which case the wall will have a uniform, and possibly a monotonous, color effect.

The wider the joints the greater will be the effect of the color of the mortar upon the wall. In an extreme case, such as shown in Fig. 19, where the bricks used are 18 in. $\times$ 2 in. on the face and the mortar joints are 1 inch in width, the areas of the brick and the mortar showing in the face of the wall are as 2 is to 1, or, the area of the mortar in the face of the wall is one-third of the entire area of the wall. It will readily be seen that in such a case the color of the mortar would be extremely important.

32. Whether the mortar in the joints is flush with the surface of the bricks or is slightly recessed also makes a great difference in the appearance of the wall. If the mortar is kept

flush with the surface of the bricks, as shown in Figs. 18 and 19, the effect of the joint depends entirely upon the texture and color of the mortar. When, however, the joints are recessed, or *raked*, each brick casts a small shadow on the mortar joint, making a dark line below and on one side of each brick, which makes the bricks stand out separately and also emphasizes the joints, as shown in Figs. 13 and 20.

33. The mortar may have a smooth or a rough texture. In Figs. 24 and 29 the mortar shows a smooth texture, in Figs. 13 and 20 a rough texture. The rough-textured mortar has a brilliancy due to the alternation of light and shade, and is generally used with a rough-textured brick.

34. Composition of Mortar for Face Brick.—For fine joints and for smooth-faced brick, a mortar made of fine sand, cement, and lime is satisfactory; and mortar colors may be added to give the mortar the desired tone or color. This mortar, however, is unsatisfactory for a joint $\frac{1}{2}$ inch or more in width, as it is too soft and pasty and would squeeze out between the bricks while they are being laid.

Practical experience has demonstrated that, with the proper kind of mortar, brick can be laid with a wide rough joint even more rapidly than with a narrow one.

35. Materials Used for Making Mortar.—Mortar for joints over $\frac{3}{8}$ inch in width should contain a liberal proportion of fine pebbles, $\frac{1}{4}$ inch or less in diameter, known to the building trade as *grit*, in addition to coarse sand, cement, and a small amount of lime putty or hydrated lime, and coloring matter if desired.

36. Grit.—Grit consists of small pebbles $\frac{1}{4}$ inch or less in diameter, and should be screened so as to remove all sand. This material gives a characteristic texture to the mortar, as shown in the joints in Fig. 13. It also gives a body to the mortar which enables it to stand up under the brick until the cement sets.

37. Sand.—Ordinary bank or pit sand is satisfactory for dark-colored joints, but where white or light-colored mortar is required, either white sand or coarsely ground marble or limestone is used. For very fine white joints pulverized marble, called *marble dust*, is used. Sand from sea beaches is not a desirable sand to use for mortar unless it has been thoroughly washed. If it is not washed the salt is apt to appear on the face of the brickwork in the form of efflorescence.

38. Cement.—The best cement to use for all brickwork is standard Portland cement. For white mortar, however, a white Portland cement, which is made from white clay and limestone and possesses the qualifications of a standard Portland cement, is preferable.

39. Lime.—*Lime putty* adds to the whiteness of the mortar and also makes the mortar work more easily under the trowel. The lime should be well slaked and strained and allowed to stand for several days before it is used.

Hydrated lime is lime artificially slaked, and is sold in the form of a very fine powder. Under most conditions hydrated lime may be used instead of lime putty. It has the advantage that it can be used immediately, whereas lime putty requires several days for preparation.

40. Coloring Materials.—Most of the mortar colors employed to color the mortar used in laying and pointing face brickwork consist of mineral pigments, and are sold either as a dry powder or in the form of pulp or paste. The pulp colors seem to mix better with the mortar than the dry colors and are therefore preferable for the better class of work. Mortar colors, whether dry or in paste form, should never be mixed with lime until the lime has been slaked for at least 24 hours. The mortar color should in any case be thoroughly mixed with the mortar, and exactly the same amount of color used for a given quantity of mortar. If this is not done there will be variations in the color of the finished mortar joints which may not be desirable.

The color of mortar appears to be much darker when the mortar is wet than when it is dry. It is therefore advisable to mix a sample of the mortar containing a measured quantity of mortar color and try it out on a small portion of the wall. This, when dried out, will show the true color of the mortar in connection with the brick. If the first experiment is not satisfactory, other mixtures of mortar can be tried until a good color is obtained. The proper proportion of mortar color having thus been determined, all mortar that is afterwards prepared should be mixed in exactly the same proportions.

41. Suggestions for Coloring Mortar.—The following are useful suggestions as to the color of mortar to be used with different colored brick.

With brick of varying shades of *red*, a cream-gray mortar, as shown in Figs. 19 and 20, is effective. Where a darker effect is desired a dark reddish brown mortar may be used.

With *gray* brick, light-gray mortar, such as shown in Fig. 24, is good. Where a thicker joint is used, a raked joint is very effective. For a darker effect, mortar of a dark gray or a dark brown, such as shown in Fig. 29, is a good color to use.

For brick of golden or buff shades, a cream-gray or warm-gray mortar is effective.

42. Formulas for Mixing Mortar.—The following formulas for mortars are the result of careful experiments and will make excellent mortars of the colors named. The term *part* as here used refers to any unit that may be used as a measuring unit. For small batches of mortar a mason's bucket of 14 or 16 quarts capacity may be used and each bucketful considered as a part. For large quantities of mortar a tight barrel, such as a Portland cement barrel, may be used as a measure of one part. It is very important that exactly the same proportions of the ingredients be used in all the batches or else each batch will show a different color in the wall, which may be very undesirable.

One of the small batches made with a bucket as the unit, mixed according to one of the following formulas, should be enough mortar to lay 100 bricks.

FORMULA I. LIGHT-GRAY MORTAR: PARTS

Quarter-inch grit	2
Coarse sand	5
Portland cement	1
Hydrated lime	$\frac{1}{2}$

FORMULA II. CREAM-GRAY MORTAR:

Quarter-inch grit	2
Coarse sand	5
Portland cement	1
Hydrated lime	$\frac{1}{2}$
Yellow powder mortar color.....	$\frac{1}{6}$

FORMULA III. DARK-GRAY MORTAR:

Quarter-inch grit	2
Coarse sand	5
Portland cement	1
Hydrated lime	$\frac{1}{2}$
Yellow powder mortar color.....	$\frac{1}{12}$
Black paste mortar color.....	$\frac{1}{16}$

FORMULA IV. DARK-BROWN MORTAR:

Quarter-inch grit	2
Coarse sand	5
Portland cement	1
Hydrated lime	$\frac{1}{2}$
Yellow powder mortar color.....	$\frac{1}{3}$
Brown paste mortar color.....	$\frac{1}{3}$
Black paste mortar color.....	$\frac{1}{30}$

FORMULA V. LIGHT-GRAY MORTAR: (For a small batch)

Quarter-inch grit	2 buckets
Coarse sand	5 buckets
Atlas cement	1 bucket
Hydrated lime	$\frac{1}{2}$ bucket
Yellow powder mortar color.....	1 pint

43. Amount of Mortar Required.—The amount of mortar required for laying face brick will, of course, depend upon the thickness of the joint used. For joints $\frac{1}{4}$ inch to $\frac{3}{8}$ inch thick between standard-sized brick, about .4 to .6 cubic yard of mortar will be required for laying 1,000 brick. For joints

$\frac{1}{2}$ inch to $\frac{5}{8}$ inch thick about .8 to .9 cubic yard, and for joints $\frac{3}{4}$ inch to 1 inch thick about 1.2 to 1.6 cubic yards, will be needed to lay 1,000 brick. One barrel of cement and 3 barrels of sand will make about 12 cubic feet, or .44 cubic yard, of mortar.

44. Finish of Joints.—It is always best to finish the joints of the face brickwork as the work progresses rather than

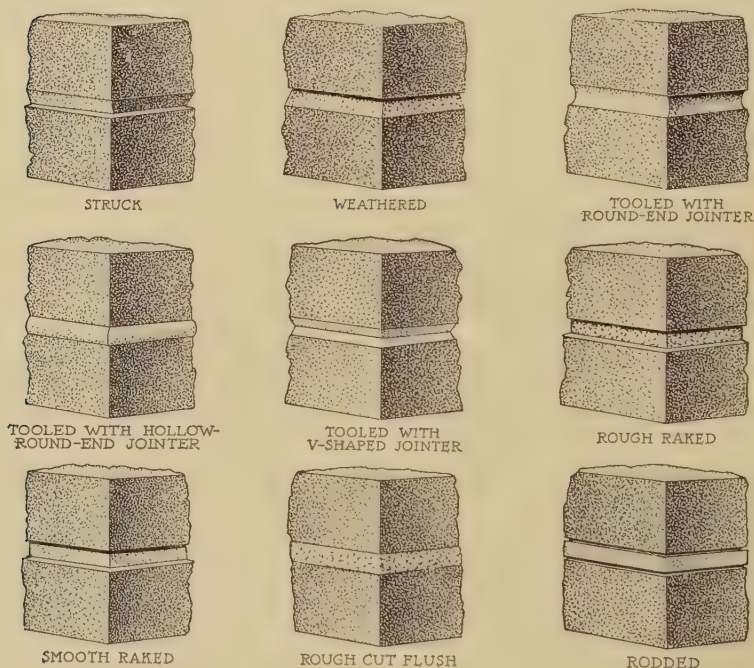


FIG. 30

to rake out the joints and point them after the wall has been built. There are several ways of finishing the joints, which have become standard, all of which have some practical or artistic merit. They are illustrated in Fig. 30.

A **struck joint** is one that is made by drawing the point of the trowel along the joint and smoothing out the mortar so that the upper edge of the joint is flush with the brick while the lower edge of the joint is slightly back of the upper edge of the lower brick.

A **weathered joint** is one made by drawing the trowel along the joint so that the mortar at the lower edge of the joint is flush with the lower brick while the mortar at the upper edge of the joint is slightly back of the lower edge of the brick above the joint.

A **tooled joint** is made with a special tool called a *jointer*, which is described later. There are three forms of the tooled joint, which are made with jointers of different shapes. These three joints are marked as tooled with round-end, hollow round-end, and **V-shaped jointers**.

A **raked joint** is formed by scratching out the mortar to a depth of from $\frac{1}{8}$ inch to $\frac{1}{2}$ inch. This is done with special tools, which will be described later. A raked joint may have a rough finish or a smooth finish.

A **rough-cut flush joint** is formed by allowing the mortar to ooze out beyond the face of the brick and cutting off the surplus with a quick stroke of the trowel just after the mortar has begun to set, but in such a manner as to avoid smoothing the surface of the mortar.

A **rodded joint** is one that is made by cutting a line along the upper and lower edges of the joint with the edge of a trowel.

45. Examples of Finish of Joints.—A *rough-cut flush joint* is illustrated in the wall shown in Fig. 19. In this example, real Roman rough-textured brick are used with a flush joint 1 inch in width. This type of brickwork is found in ancient Roman buildings.

Fig. 20 illustrates the use of a rough-textured brick and a rough raked joint. The brick are laid up in English bond. In Fig. 29, smooth-textured mottled brick of standard size are shown laid up in Flemish bond with smooth raked joints of dark-brown mortar.

46. A mortar joint that is decidedly black or white is to be avoided. The black joint has a deadening or dulling effect on the general color of the mass of brickwork, while the white mortar looks too bright and new and generally makes too sharp a contrast in color with the brick.

47. Tools Used in Finishing Joints.—The *trowel* is used to make the struck joint and the weathered joint and, in connection with a straightedge, in forming the rodded joint.

The tooled joint is made with a tool called a *jointer*, *jointing tool*, or *jointing steel*. Forms of jointers are shown in Figs. 31, 32, and 33. The jointer shown in Fig. 31 consists of a piece



FIG. 31

of flat steel bent as shown and with the edges *d* and *e* made of different shapes so as to produce the different forms of joints. Three of these shapes are shown at *a*, *b*, and *c*. The mortar joint is finished by drawing the jointer along between the edges of the bricks and pressing it against the mortar. The jointer forms the joint according to the shape of its edge. The edge *a* makes a hollow joint, the edge *b* forms a *beaded* or projecting half-round joint, while the edge at *c* is used to form a **V**-shaped joint. These joints are shown in Fig. 30.

48. Another form of a jointing tool is one that has a circular cross-section and a tapering point, as shown in Fig. 32.

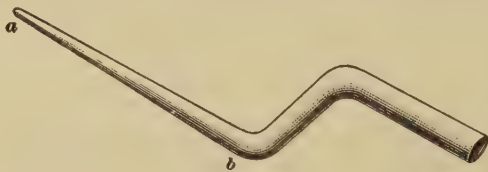


FIG. 32

The fine point at *a* is used in pointing the finer joints, and the thicker part *b* is used for coarser joints. This tool is used only for hollow joints.

A similar jointer, also circular in section, is shown in Fig. 33 (*a*). The jointer tapers so that it can be used for joints of different widths.

49. Tools for Raking Joints.—A simple device for raking the mortar out of the joints to form a raked joint is shown in Fig. 33 (b). It consists of a flat steel bar with projections on each end which are the shape of the joint to be raked. The same tool can be used for raking two different sized joints. The projection *a* or *b* is drawn along in the joint and cleans out the mortar according to its length and width. The shoulders *c* prevent the joint being scratched out beyond the desired depth.

50. A patented device for raking out and striking a raked joint is shown in Fig. 33 (c). This tool consists of a handle *a*

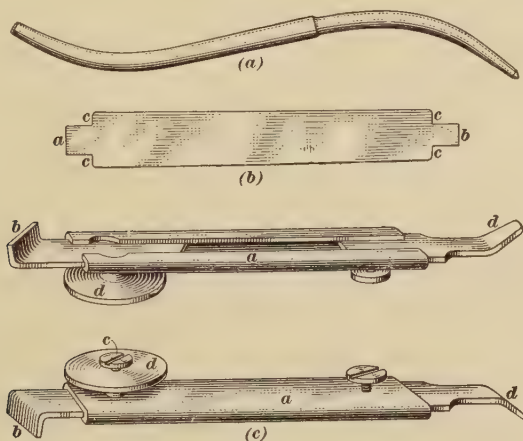


FIG. 33

into one end of which *joint scrapers*, or *plows*, *b* can be fitted. Different sizes of plows are used according to the thickness of the joints. The plow can be extended to cut any depth of joint required, and is held firmly to the handle by means of a screw bolt *c*, the head of which is shown above the wheel *d*. This wheel runs along on the face of the brick as shown in Fig. 34 at *a* and regulates the distance that the plow enters the joint. Thus, when the tool is run along the face of the wall it rakes the mortar out of the joint to the desired depth, forming a rough raked joint.

In the other end of the handle, Fig. 33 (*c*), *strickers d* of different widths can be secured. These strikers are used to smooth the raked joint, as shown in Fig. 34 at *b*, thus forming a smooth raked joint.

51. Pointing.—Pointing consists of scraping the mortar out of the joints to the depth of about $\frac{3}{4}$ inch and filling them with fresh mortar. The joints are raked out with a piece of

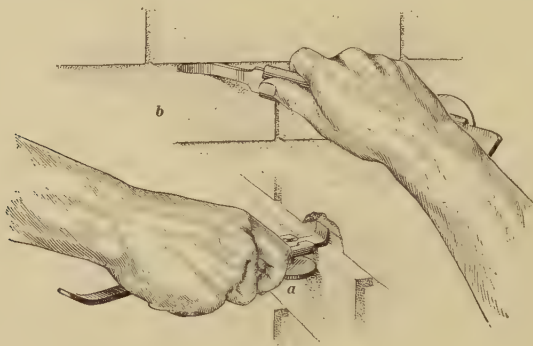


FIG. 34

wood or iron or with a tool such as has just been described. After raking, all the loose mortar should be brushed out of the joints and the joints made wet so that the pointing mortar will stick to the brickwork. The same quality of mortar should be used as for face brickwork and the joint may be finished in any of the styles shown in Fig. 30.

BOND

52. General.—The appearance of a brick surface depends not only upon the color and texture of the brick and the mortar but, to a very large extent, upon the manner in which the brick is bonded or laid in the wall.

Bonding is primarily a means of construction and is a method of tying the bricks together in such a way as to make the wall structurally solid and strong.

Face bond is the bond used on the face of the wall, and it is often independent of the structural bond of the backing.

In discussing bond or bonding in connection with face brickwork the face bond only is referred to.

53. Bonds.—There are four structural bonds that are also largely used in face brickwork. They are the *running* bond, the *Flemish* bond, the *English* bond, and the *Dutch* bond.

54. Running Bond.—The simplest bond, as far as appearance is concerned, is the *running* bond, which shows only stretchers on the face of the wall. These stretchers break joint as shown in Fig. 13. This arrangement of the bricks does not provide headers to tie the face brick to the backing, hence the tie must be provided by other means. The methods employed to tie the face brick to the backing are by means of metal ties; by clipping off the interior corners of the face brick

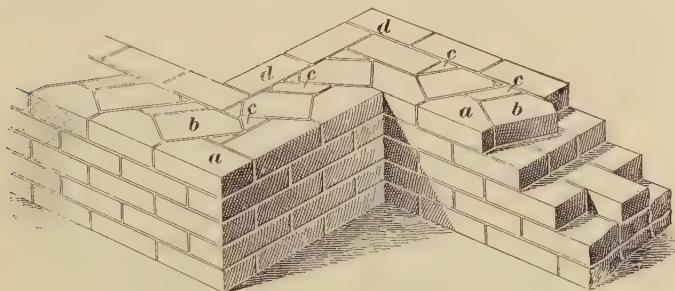


FIG. 35

and laying the interior bricks diagonally to form a bond, as shown in Fig. 35; by cutting the face brick in half lengthwise and *toothing* the backing into the space thus formed, as shown in Fig. 36.

55. Flemish Bond.—The *Flemish* bond consists of alternate headers and stretchers in each course, each header in one course being directly over the center of the stretcher in the course below. This bond is shown in Figs. 17, 18, 19, 21, 22, and 29, and is very decorative in its effect. It is particularly effective when the headers are slightly darker than the stretchers, as in Figs. 19 and 22.

A variation in this bond is illustrated in Fig. 37, where the stretcher consists of two standard-sized stretchers with a blind joint between them.

56. English Bond.—The *English* bond consists of alternate courses of headers and stretchers and is a substantial-

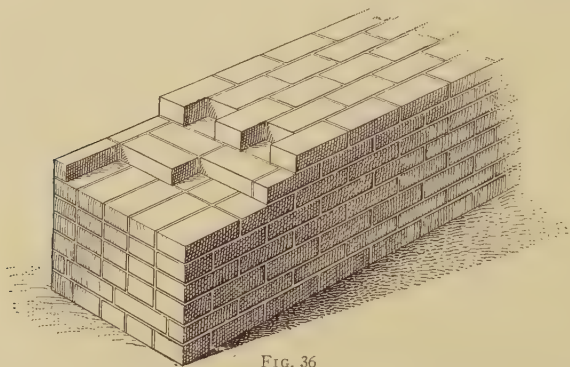


FIG. 36

looking and fine-appearing bond. It is also simple and easy to lay up.

An example of this bond is shown in Fig. 20. A great deal of the historic brickwork of England is laid in this bond and it is a very popular bond in the United States. Often, in practice,



FIG. 37

only the headers of every third or fourth course in the face brick extend into the backing to form a bond or tie, or some-

times only a portion of the course extends into the backing. The stretchers in all courses are in line vertically.

57. Dutch Bond.—The *Dutch* bond is a modification of the English bond and it also consists of alternate rows of headers and stretchers. In the Dutch bond the stretchers in one course break joints with the bricks in the next stretcher course above and below, and the headers are all centered on the stretchers either above or below them. The result of this



FIG. 38

arrangement is that the vertical joints form a diagonal pattern over the entire face of the wall, which has a very artistic appearance.

This bond is also known as the *Dutch cross bond* or the *English cross bond*, and is illustrated in Fig. 38.

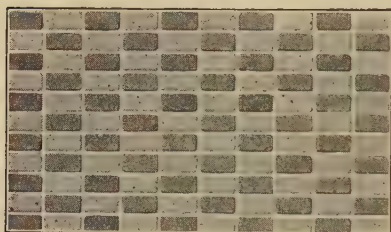
58. American, or Common, Bond.—The bond called American, or common, bond is made by introducing a course of headers, called a *bond course*, every fifth or sixth course. This bond is the one generally used in building ordinary brick walls in the United States, and is also sometimes used as a face bond.

59. Miscellaneous Bonds.—Besides the bonds that have just been described, which may be considered as the

standard bonds used in brickwork, there are many other bonds, most of which are variations of these standard bonds. These more complicated bonds, however, are used merely for their decorative effect and should properly be considered under the subject of Pattern Work.



(a)



(b)



(c)

FIG. 39

stretchers, while the patterns in (b) and (c) are formed entirely of headers. The brick in (a) must be tied to the backing as described for running bond. The brickwork in (b) and (c) can easily be tied to the backing by allowing headers to extend back into the wall as frequently as may be desired. Most of the headers shown in (b) and (c) are bats or half-bricks. These patterns may be formed by the

PATTERN WORK

60. Pattern Work on Wall Surfaces.—Pattern work is formed by arranging the bricks and joints according to some pleasing design, also by varying the color, texture, and sizes of the brick. The bonds already shown give simple and more or less pleasing patterns, and some of the more complicated bonds will next be considered.

61. Variations of the Running Bond.

Three variations of running bond are shown in Fig. 39 (a), (b), and (c). The pattern at (a) is formed of

arrangement of the joints only or by the use of bricks of different colors or textures.

62. Variations of the Flemish Bond.—The arrangement of the joints in Flemish bond does not permit of any modification but there is a great variety of pattern work that can be produced by the use of different-colored brick. Some of these patterns are shown in Fig. 40. The pattern in (c) is the one which is very popular and is used frequently.

63. Variations of the English Bond. Variations in pattern, using English bond, are made by using bricks of different colors as shown in Fig. 41.

64. Variations of the Dutch Bond.—Variations in pattern in the Dutch bond can be made only by the use of different-colored bricks. Two patterns are shown in Fig. 42.

65. Miscellaneous Patterns.—There are innumerable patterns that can be made on wall surfaces by manipulating the jointing and the colors of the bricks.

A great number of patterns are formed by using a course of stretchers alternating with a Flemish course. Several of these patterns are shown in Fig. 43. In (a) is shown a pattern that will have the effect of vertical lines of differing thickness;



(a)



(b)



(c)



(d)

FIG. 40

at (b) is a pattern of small crosses extending over the entire field; (c) shows a pattern in which all the headers are darker in color than the stretchers.



FIG. 41

browns, and soft purples, laid up with a cream-gray flush joint, gave the finished brick surface an artistic and decorative effect.

Other patterns are shown in Figs. 45, 46, and 47. Intricate and exceedingly interesting patterns are shown in the Persian minaret in Fig. 8.

Various designs for wall patterns will be found in the illustrations shown in this Section and the student will find it interesting and profitable to study them and determine how they are formed.

The simplest designs to execute, so far as the mason is concerned, are those in which standard-size brick are used, and in which the pattern work does not interfere with the

The pattern shown at (d) has a diamond effect. The pattern at (e) is one that is formed largely by the joints and has a refined and artistic effect. A portion of wall laid up with this design, but without a difference in the brick coloring, is shown in Fig. 44.

In this particular example, rough-textured brick of various shades of reds,



FIG. 42



(a)



(d)

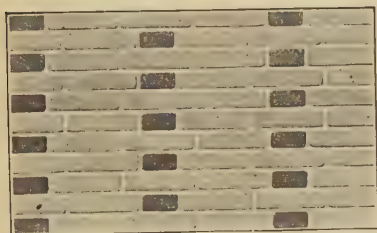


(b)



(e)

FIG. 43



(c)



FIG. 44



FIG. 45

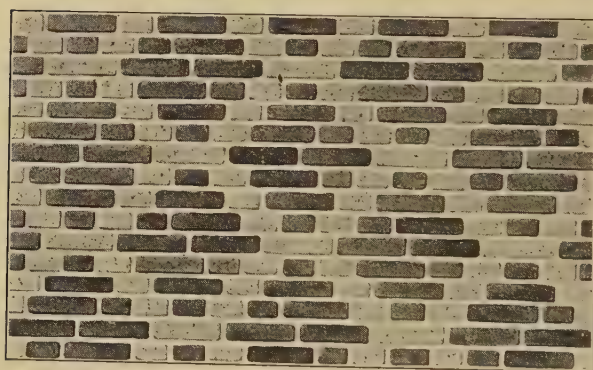


FIG. 46

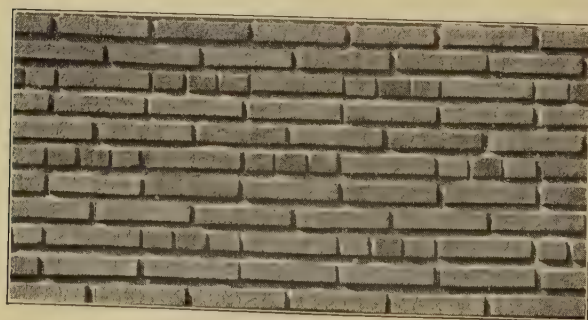


FIG. 47

particular bond used in the general field. An example of this is shown in Fig. 48.



FIG. 48

66. When diagonal patterns such as shown in Figs. 43, 44, 45, and 46 are used, care should be taken in designing the façade so that the pattern will have a proper relation to the

openings and corners of the wall. Thus, the pattern should meet both sides of a window symmetrically, as shown in



By courtesy of Fiske & Co., Inc.

FIG. 49

Fig. 44, and make a neat finish at the corner of a wall, as shown in Fig. 49.

67. Herring-Bone Pattern.—A pattern known as the *herring-bone* pattern, which is very much used in paneling, is

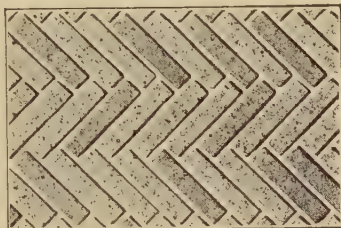
illustrated in Fig. 50. Designs such as shown in (a) are adaptable to running bands or friezes. The designs in (b) and (c) are useful for panels. These patterns, particularly (b) and (c), are also very much used in floors made of brick or tiles.

68. Friezes and Bands.—As a rule, it is best to keep the patterns used in large brick fields rather quiet and subdued and to emphasize some band or frieze or some particular spot by a more interesting and elaborate treatment. The plainness of the field will then set off to advantage the more complicated design of the frieze or spot, and produce a more satisfactory result. This method of treatment is illustrated in Figs. 51, 58, and 63, where ornamental bands are used in connection with plain fields, also in Fig. 1, where a plain field in Flemish bond is surmounted by handsome friezes or bands of patterned work which crown the wall. Fig. 51 illustrates the effectiveness of ornate bands or friezes over a plain wall.

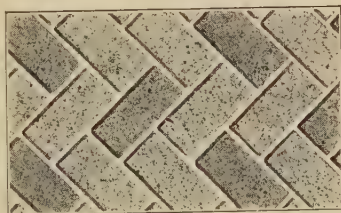
69. Designs for bands in face brickwork are given in Figs. 52, 53, and 54. Fig. 52 shows a *chain pattern* formed in Flemish bond, Fig. 53 is a *chain pattern* in English bond, and Fig. 54 is a more complicated pattern showing the use of special-sized brick, which have already been described. These effects are produced by differences in the color of the brick as well as by the bonding. Other designs for bands are shown in Figs. 1, 64, and 65.



(a)



(b)



(c)

FIG. 50

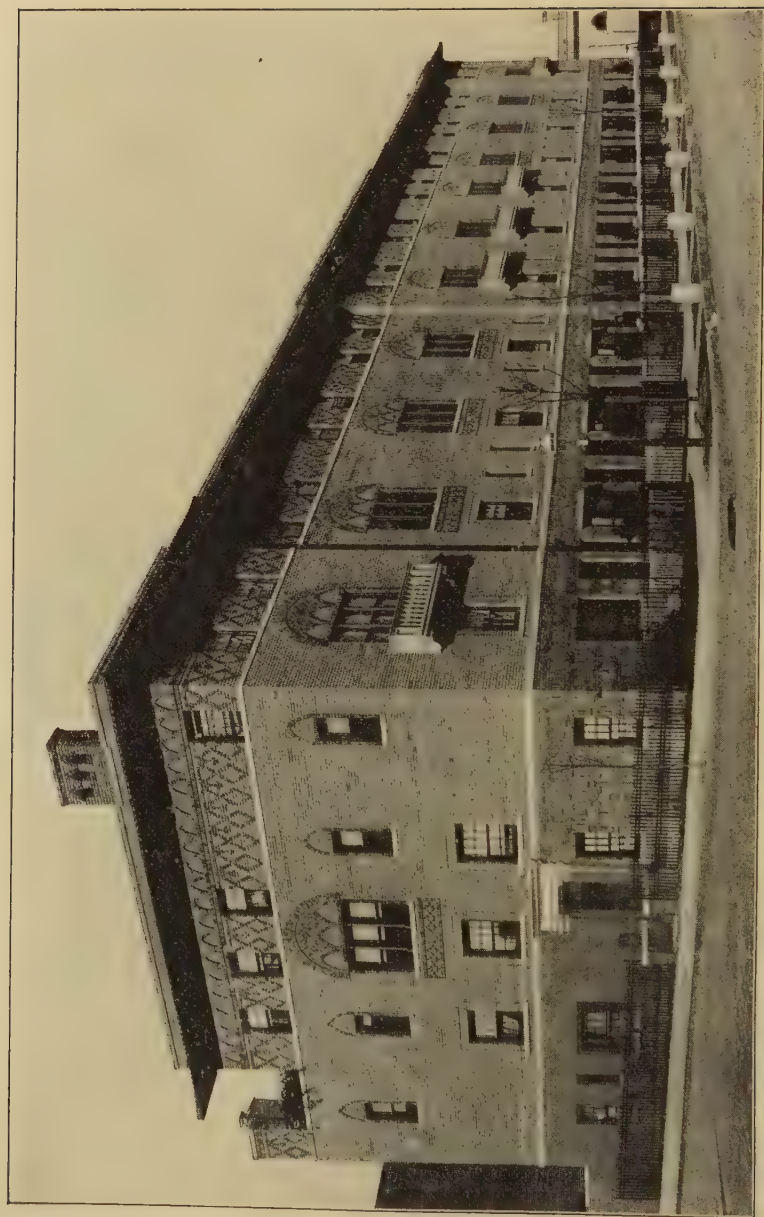


Fig. 51



FIG. 52



FIG. 53

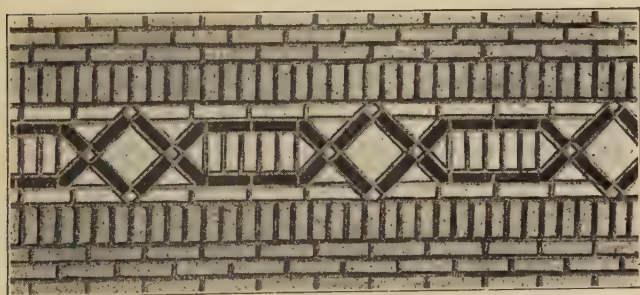


FIG. 54

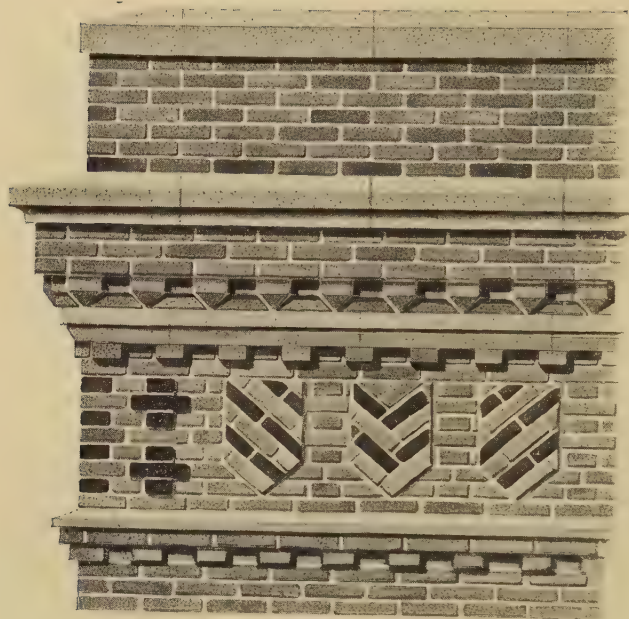


FIG. 55

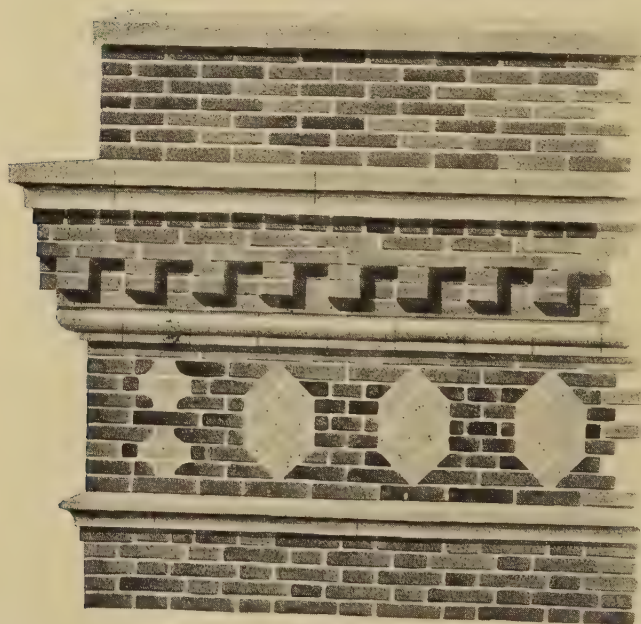


FIG. 56

Friezes containing special designs made of brick cut to various shapes and representing shields, hexagons, etc. are illustrated in Figs. 55 and 56.

70. Borders.—Borders are used around large panels such as frequently occur on school buildings, theaters, and factory buildings, which, if not especially treated, would appear uninteresting. Fig. 48 suggests a treatment of a large panel and border in a brick building which makes it interesting without using special brick and at very little expense more than would be incurred in making a plain wall.

A design for a border is shown in Fig. 57 in which the bands *a, a* as well as the corner pieces *b* are raised above the field about $\frac{1}{2}$ inch. The headers may be black headers where so indicated or else brick of a slightly darker color than the rest. The pieces *b, c*, and *d* may be tiles or bricks of special shape and different color from the brickwork of the field. A handsome border, used around a panel on an interior wall, is shown in Fig. 58.

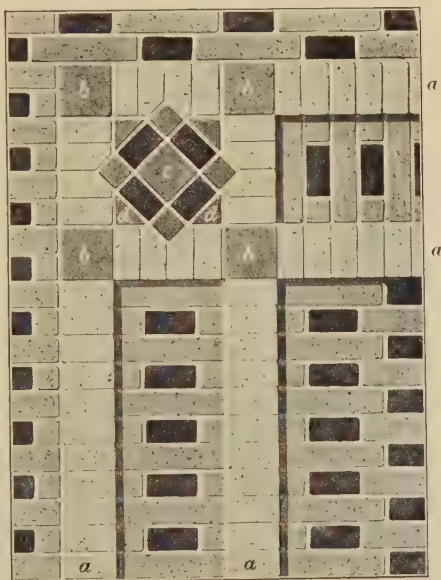
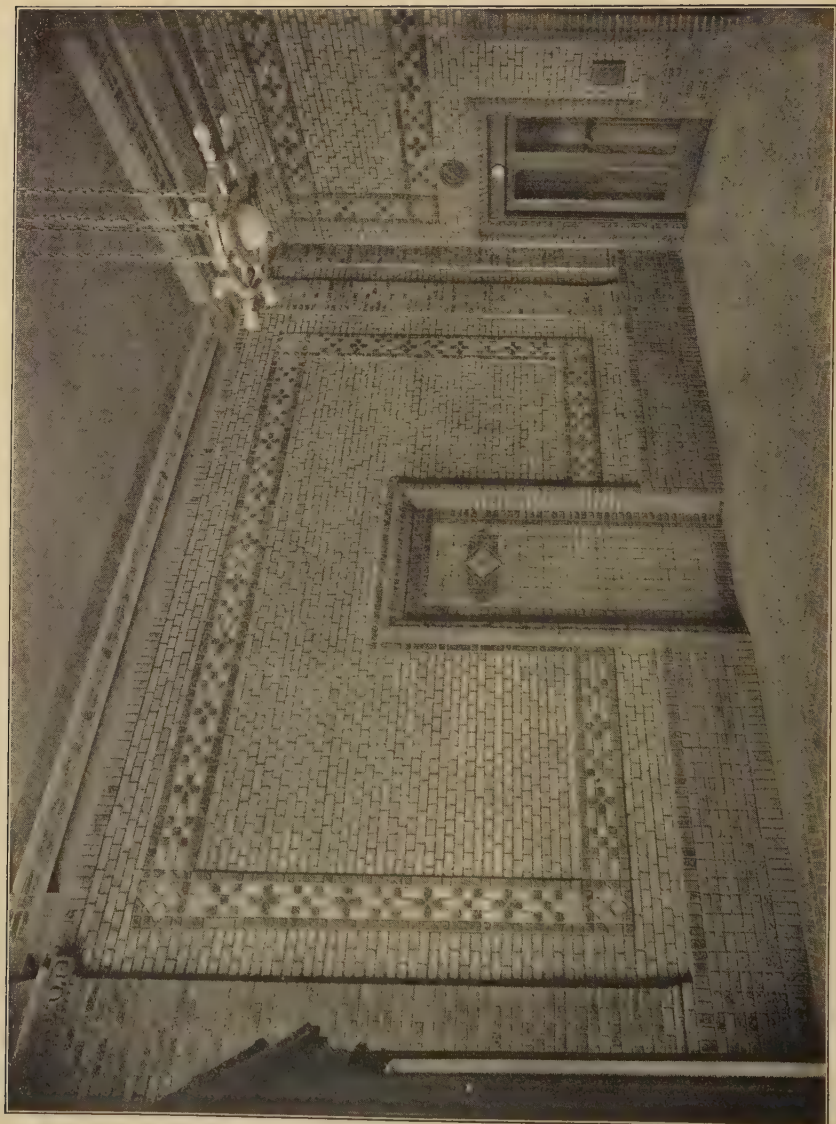


FIG. 57

71. Panels.—Panels are shown in Figs. 48, 58, 59, and 60. In Fig. 48, a large panel is formed by a border of headers and rowlocks, with the corners emphasized by bricks set on end, in soldier courses. Two points or spots in the field of this panel are brought out by special patterns. This wall is an example of a wall laid in English bond where the stretchers are darker



By courtesy of Fiske & Co., Inc.

FIG. 58

than the headers. The entire wall has a distinctly interesting brick character.

Fig. 58 illustrates a plain brick panel surrounded by an interesting border.

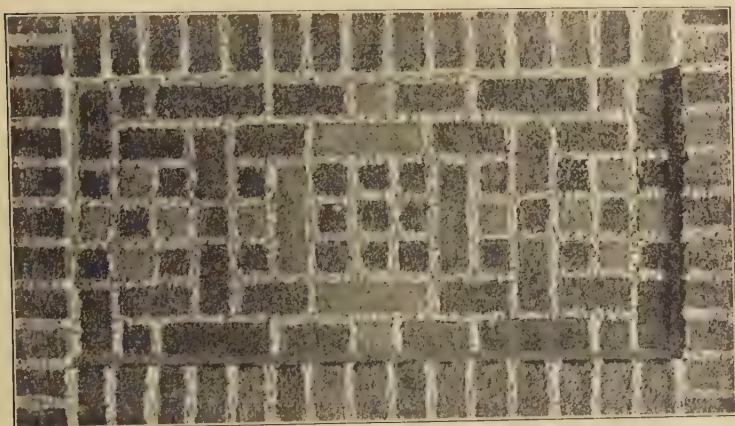


FIG. 59

The panel in Fig. 59 is an excellent example of modern brickwork in imitation of the ancient Persian work. There

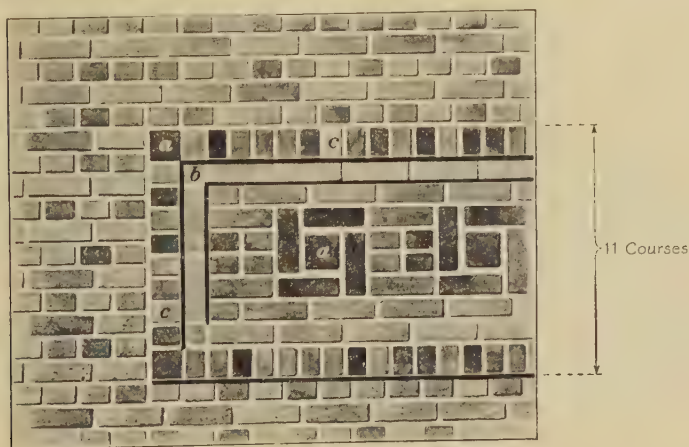


FIG. 60

are three sizes of units used in this design. The standard-size stretcher, 8 in. $\times$ 2 $\frac{1}{4}$ in., is one unit, a second is 5 in. $\times$ 2 $\frac{1}{4}$ in., and

the third is $2\frac{1}{4}$ in. $\times$ $2\frac{1}{4}$ in. The joint used in this design is $\frac{5}{8}$ inch thick, so that three rowlock bricks in the border and two joints equal one stretcher, two of the rowlocks plus one joint equal the 5-inch unit, and one rowlock equals the third

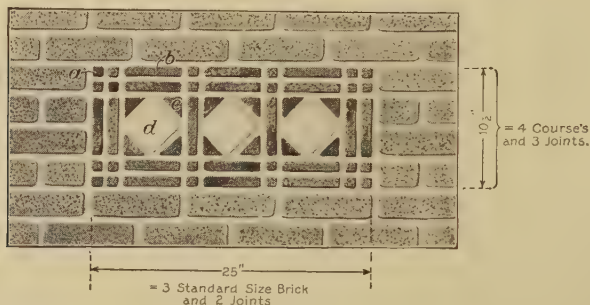


FIG. 61

unit. This combination of units lends itself to many handsome patterns. An application of this kind of panel work is shown below the frieze in Fig. 1.

Fig. 60 illustrates a simple panel design in which the border *c* has been projected slightly beyond the face of the wall. The pieces *a* and *b* are special sizes of brick made for this pattern.

The panels shown in Figs. 61 and 62 depend upon the proper selection of colors in the bricks and upon the contrast in color between the mortar and the brick. In Fig. 61 small dice 1 inch



FIG. 62

square are shown at *a*, pony size brick at *b*, triangular cuts at *c*, and square tile or brick at *d*.

The application of panels to the decoration of a building is shown in Fig. 63 immediately beneath the cornice, between the

uppermost windows, and in the frieze at the top of the bay windows.

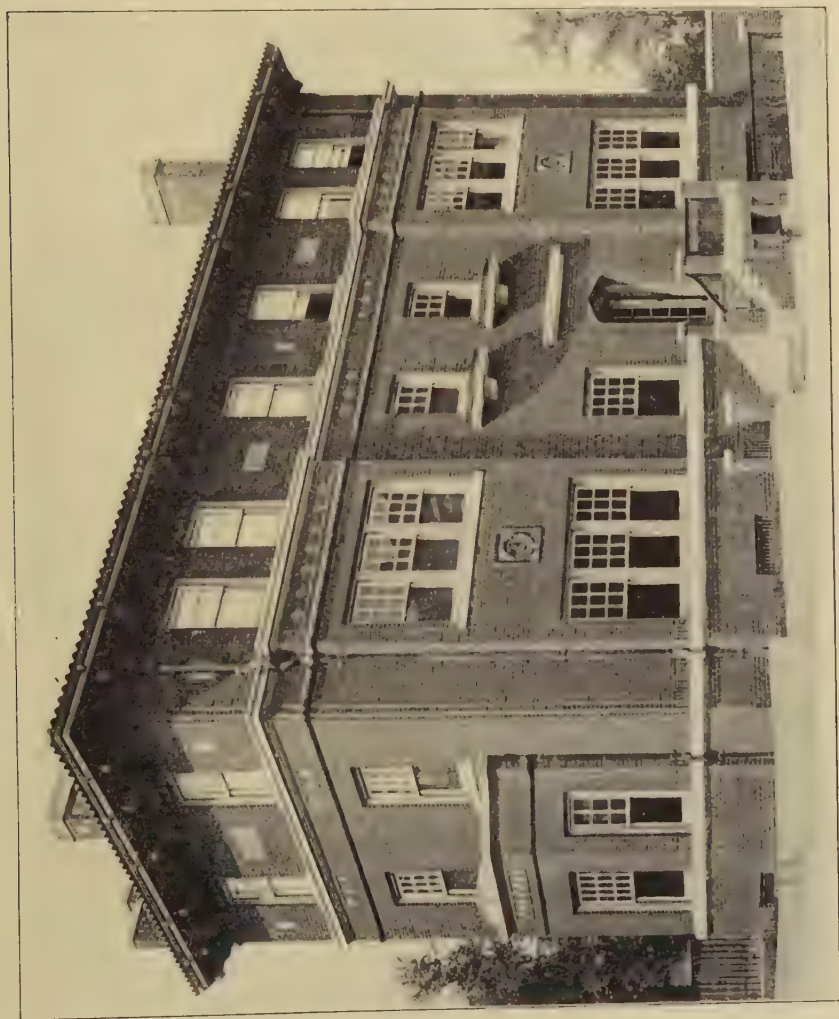
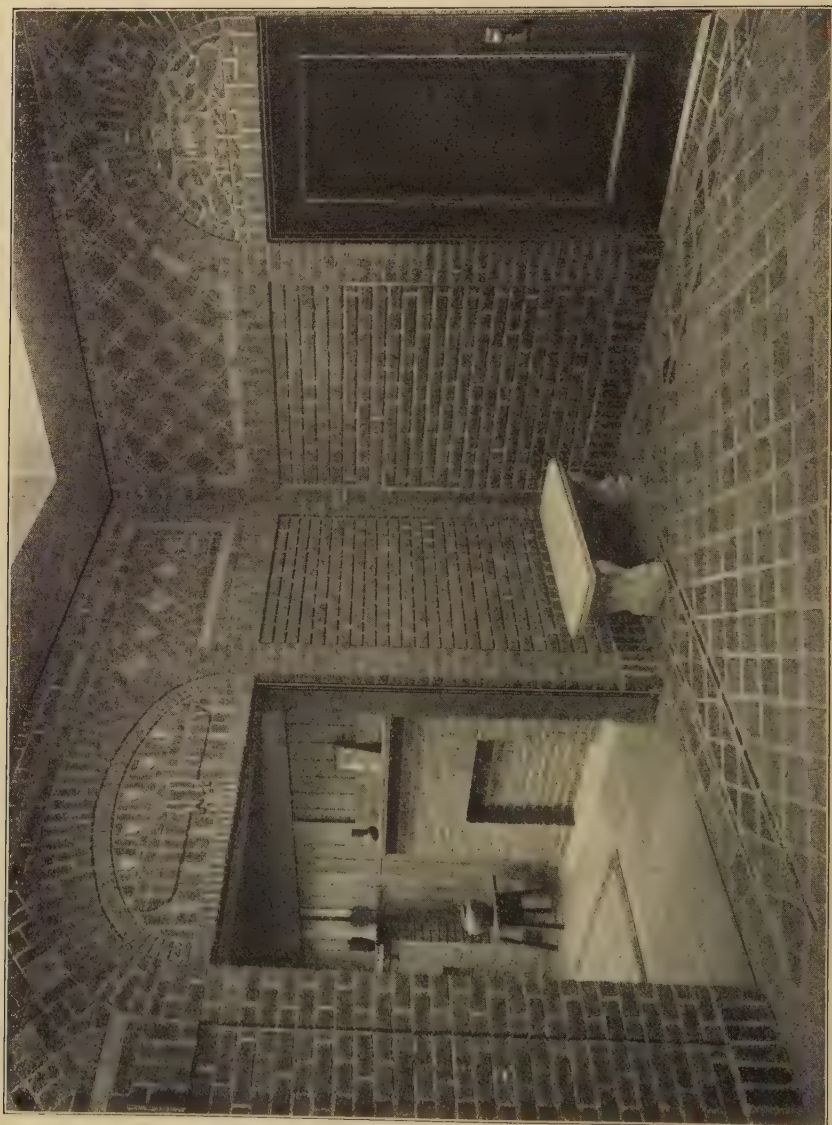


FIG. 63

72. Interior Walls.—With the great variety of color and texture found in modern brick, interior walls can be designed that are very suitable for vestibules, conservatories,



By courtesy of Fiske & Co., Inc.

FIG. 64



FIG. 65

By courtesy of Fiske & Co., Inc

cafés, etc. Fig. 58 illustrates the use of brick in the main entrance lobby of a large business building, in which many of

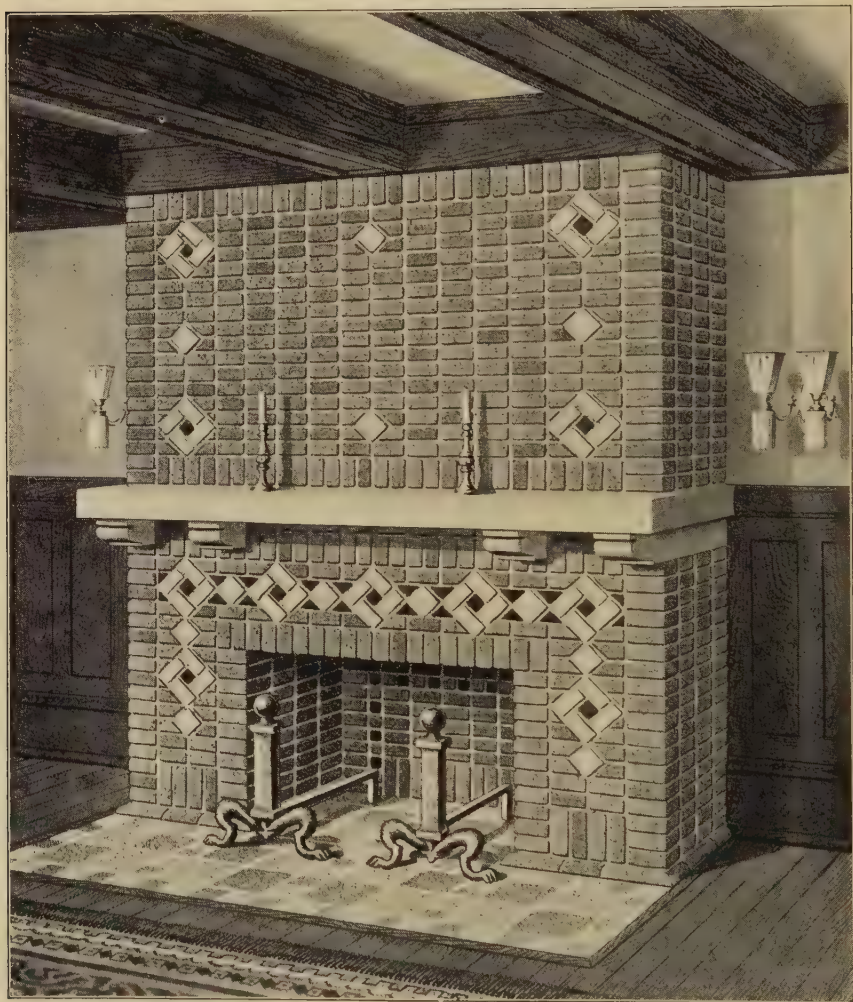
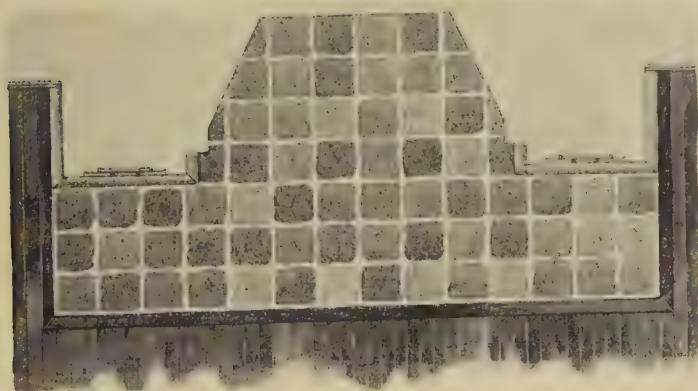
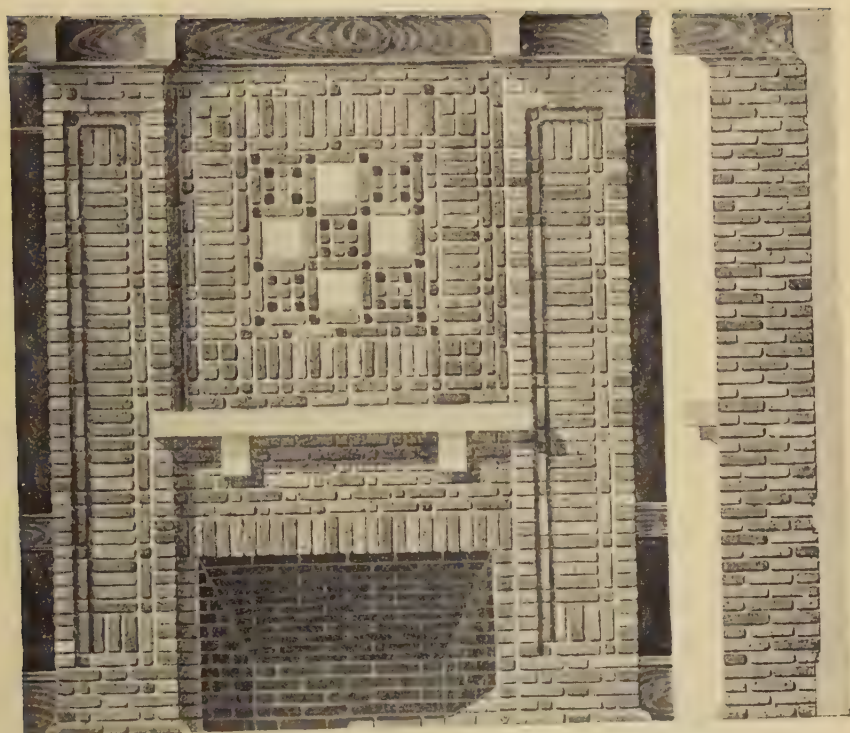


FIG. 66

the resources of face brickwork are exhibited. A soldier course occurs at the base of the wall, above which is shown a running bond of headers and a rowlock course. These form



a wainscot effect. Above this the wall is paneled, the panel being surrounded by a handsome border. The field of the panel is in Dutch bond. The trim or finish of the door openings is formed of molded brick similar in character to that of the other brick in the wall.

Figs. 64 and 65 show the treatment of walls in face brick as used in the display rooms of a prominent brick manufacturer. These walls show a variety of friezes and bonds, the use of soldier courses, friezes, bands, panels, etc. They also illustrate the use of Flemish, English, and Dutch bonds in the field, and the various special shapes of brick. Tile inserts showing dolphins and a ship are used over one doorway in Fig. 64 and an ornamented brick panel is shown over the other doorway.

73. Fireplaces.—Face brick are frequently used with artistic effect in the construction of fireplaces and chimney breasts. Figs. 66 and 67 are examples of such fireplaces. By the proper selection of colors and sizes of brick these fireplaces make very effective and ornamental features for sun parlors, living rooms, dens, and libraries.

ORNAMENTAL BRICKWORK

74. As has been stated, **ornamental brickwork** may be formed of plain brick which is built so as to project and form cornices, string-courses, and other ornamental features, or by the use of bricks which are molded into special shapes before baking.

An example of plain bricks used in forming a cornice is given in Fig. 68 in which an approximation to a classical cornice has been built as far as can be done with brick. The bottom of the cornice begins with a rowlock, or bull-header, course. Most of the projections are necessarily slight. The bold projection in the upper part of the cornice is made with especially large bricks or units which support the crowning member. A band course at the middle of this cornice is formed by building the bricks in a diagonal position so that the corners project.

This causes a variation of light and shade on the different surfaces and a wavy effect in the mortar joints. This cornice is crowned by a terra-cotta molding course. Just below the cornice are seen three tiles inserted in the brick field.



FIG. 68

Another example of ornamental brickwork formed of projecting bricks is given in Fig. 69. In this figure the outer ring of the arch is a rowlock arch and inside of this arch is a dentil

course, so called from its resemblance to a row of teeth. The string-course above the doorway is supported upon brackets

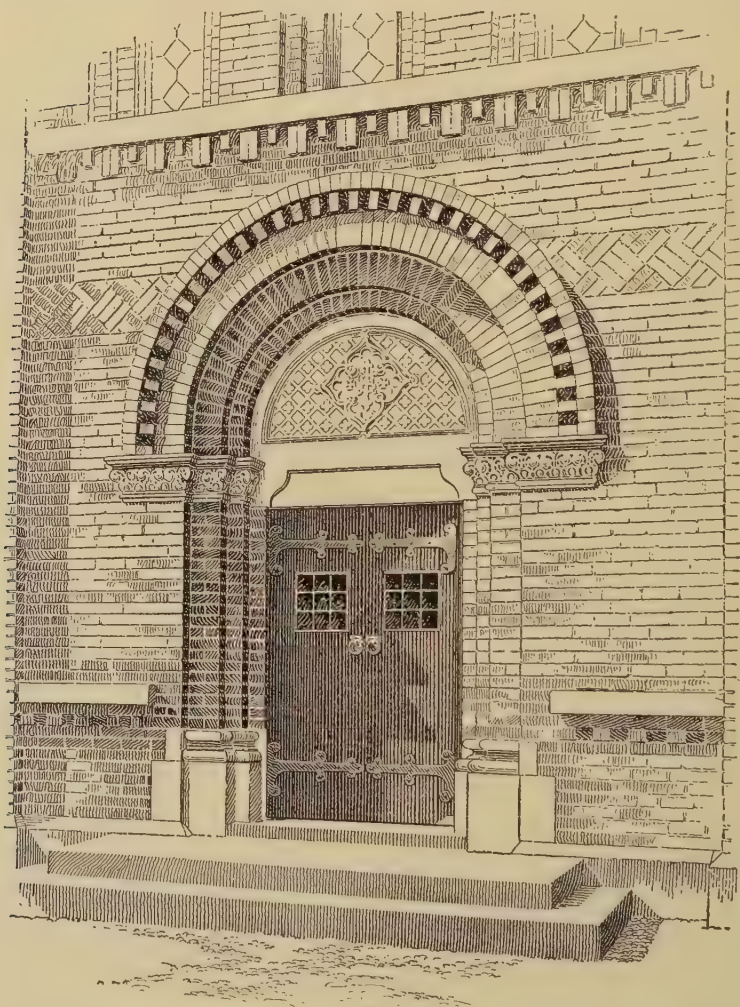


FIG. 69

formed of bricks placed on end alternating with bull headers.

Figs. 6 and 7 show examples of Italian ornamental brickwork of the 13th and 14th centuries.

ARCHITECTURAL TERRA COTTA

ADVANTAGES, USES, AND DESIGN

INTRODUCTION

1. *Terra cotta* such as is used for facing walls of buildings, forming cornices, columns, sills, and lintels over openings, etc., is technically known as *architectural terra cotta* to distinguish it from the form known as *structural terra cotta*, which is used in the construction of walls, partitions, floor arches, and enclosures for steel columns in fireproof buildings.

2. All *terra cotta* is made of clay or shale, which is ground with water in a mill, molded into shape, and then placed in a kiln and burned to a brick-like consistency. Architectural *terra cotta* is made of a better grade of clay than structural *terra cotta* and is so treated as to form a plastic mass that can be molded into forms of very intricate pattern. Great care is required in forming and handling the blocks, in finishing the surfaces, and in burning, to secure a product that will be free from defects and suitable for the purpose intended.

Although the process of manufacture has changed greatly in detail since *terra cotta* was first employed, about 600 B. C., the product as it comes from the kiln today is very much the same as that made by the ancients, who used this material for a variety of useful and ornamental purposes.

3. *Terra cotta* is extensively used for facings for exterior and interior walls of buildings, and for such purposes it is a durable, beautiful, and economical material.

Properly made terra cotta is fire-resistant, frost-proof, and weather-proof, in which characteristics it is superior to stone. It lends itself to a great variety of color effects and can be molded or ornamented with comparative ease to produce either plain or intricately ornamented work that will stand the wear and tear of centuries.

From the structural standpoint, terra cotta is a most desirable material to use on account of its durability and adaptability to many kinds of structures. It is equally adaptable to a building having masonry walls or one having a framework of steel or of reinforced concrete.

ADVANTAGES AND USES OF TERRA COTTA

4. Facings for Walls.—Terra cotta, when used as a facing for masonry walls, may be bedded in mortar and built into the wall in the same manner as stone or brick.

As a facing for a steel-frame or reinforced-concrete-frame structure, terra cotta is a desirable material, as the blocks may be designed and formed to fit the shape of the structural parts that support them. The blocks may be kept away from these parts a distance of from one to two inches to allow for irregularities in the structure, thus avoiding expensive cutting and fitting such as is often required when stone is used. In the forms of structures mentioned the terra cotta is usually attached to the supports by means of metal anchors, and the space back of the blocks is filled with masonry except in places where the terra cotta fits closely to the supports, in which cases the space may be filled with a cement grout.

5. An advantage that terra cotta has, when used as a facing for a reinforced-concrete building, is that the entire rough concrete structure can be built and completed on the inside before the terra cotta is applied. The terra cotta does not require to be bonded with the wall, piece by piece, as the wall progresses, but may be put in place afterwards and secured to the wall by means of metal anchors that have been previously built into

the wall. By this method, the terra cotta may be in the making at the factory while the building is being erected.

6. In addition to the employment of terra cotta for building fronts and for interior work, there is considerable demand for its use in cornices and balustrades to take the place of more expensive cut stone, copper, or perishable sheet metal, such as tin or galvanized iron.

7. Fire-Resisting Qualities.—Terra cotta is a good fire-resisting material, as it can stand the heat of a conflagration better than stone. It can therefore be used in office buildings and other structures where it is necessary to cover a steel frame with a material that will conceal and protect the steel and at the same time give a pleasing and permanent architectural finish to the structure.

8. Weather-Resisting Qualities.—As a weather-resisting material, architectural terra cotta is very superior. When properly glazed it is non-absorbent and is thus excellent for structures built in large towns and cities where smoke and dust are always in the atmosphere. Terra cotta can be so glazed that it is impervious to water, and buildings faced with it can be washed down whenever desired, and made to look as fresh as when new.

9. Lightness in Weight.—For special purposes where a saving in weight is necessary, terra cotta is especially useful, as in a dome where it is required that the structure shall be light in weight and at the same time durable and weather resisting.

10. For Ornamental Work.—Terra cotta as a material for ornamental work in buildings has several advantages over cut stone which make it especially desirable to use under some circumstances. One of these is that the sculptor who models any ornamental part of a building in terra cotta can be sure that his model will be accurately reproduced, because the process of casting terra cotta is a mechanical one by which the original model made by the sculptor is exactly copied in

the plaster mold and reproduced in the clay when pressed into the mold.

When stone is used, the sculptor makes a clay model from which a plaster cast is taken and this is copied by the stone carvers with more or less fidelity, according to their proficiency and the accuracy with which they can interpret the sculptor's original model. As a rule, sculptors themselves do not carve the stonework but are dependent for the excellence of the results upon the skill of the stone cutters employed by them.

11. Another advantage is that terra cotta can be glazed with any color desired, so that great variety in tint can be obtained; thus it is not dependent upon its natural color, like stonework, nor upon the color produced by the burning, as is the case with brickwork. The ability to glaze terra cotta with colors opens up a wide range of possibilities for the designer who appreciates the effectiveness of color in his designs. Color in terra cotta is not affected by time or weather. Though dimmed by dust or smoke, the material may be quickly restored to its original color by washing. Colored glazed terra cotta is called Faience or *polychrome* terra cotta, *polychrome* meaning many colored.

White, full-glazed terra cotta, described later, is especially useful for the fronts of buildings, for lining light-courts, or wherever it is desirable to reflect the light as much as possible.

12. Economy.—Terra cotta also has an advantage in economy, as it generally costs somewhat less than stone, and being lighter in weight requires less steel to support it.

Terra-cotta members having richness of detail, such as flutings, ornamental panels, belt-courses, elaborately modeled column capitals, or similar members, can be produced in duplicate at much less expense than in cut stone, each unit of which must be laboriously carved by hand. Even in the plain members that are often used as a facing, the blocks may be formed of practically one size and by the use of very few molds may be cast in great numbers, whereas in stone facings each piece requires to be cut and finished as a separate unit.

DESIGN OF TERRA COTTA

13. In designing buildings in which architectural terra cotta is to be used, the architect should have a good knowledge of the nature of terra cotta, as well as of some of the peculiar conditions that govern its manufacture. Architectural terra cotta should be designed in accordance with the characteristics of the material itself even when it is used to resemble some other material, such as cut stone.

CHARACTERISTICS AFFECTING DESIGN

14. The characteristics of terra cotta that affect its use and design are, first, that terra cotta is a burnt product that shrinks and warps somewhat in burning. This characteristic makes it difficult to use large pieces of terra cotta in plain-surface work, as irregularities in the surface will not look well in the front of a building. This defect is largely overcome by using the terra cotta in medium-sized blocks so that the deformities will be small and practically negligible.

A second characteristic is that the clay of which the terra cotta is made lends itself readily to modeling or ornamentation. The use of modeling or ornament over the surfaces of terra-cotta work serves to conceal deficiencies due to warping and shrinking, and terra-cotta work containing considerable ornamentation always looks better than plain work. This modeling can be done quite easily and, after a mold has been made for a piece of ornament, a great number of similar pieces can be cast in the same mold. Hence, the oftener an ornament is repeated on a surface the less will be the cost of the terra cotta per piece, as the repetition of the same pattern will be much cheaper than the use of a number of different patterns.

A third characteristic is that very elaborate, bold, and projecting ornament for special positions can be easily made in terra cotta. The modeler makes the desired form in clay and the model is cut up into suitable-sized pieces, dried, glazed, and baked.

A fourth characteristic of terra cotta is that it can be colored in any desired tints and thus a field for design in color is opened to the designer.

A fifth feature is that it can be finished so as to resemble other materials, especially cut stone.

Thus terra cotta lends itself readily to ornamental treatment either of a bold or a delicate nature, to elaborate or delicate color effects, and to texture design.

PLAIN SURFACES

15. Plain Blocks.—Where plain blocks are used to obtain certain features, such as ashlar faces, plain piers, mullions and panels, they should be medium in size and carefully finished before drying, and the joints should be rubbed so that the two adjoining blocks will fit together with perfect accuracy. A wall composed of plain blocks that are even slightly warped will have an uneven appearance, but if the blocks are paneled, molded, or ornamented in any way that tends to make the wall irregular in appearance, the eye will not notice any slight warping that may exist.

The effect of the shrinking and warping in plain blocks of terra cotta, due to the heat of baking, is shown in the flat portion of the wall above the second-story windows in Fig. 1. If, however, this part of the façade had been built with blocks about 10 in.×16 in. or 12 in.×20 in. in size, as has been done in the panel between the first- and second-story windows, these blocks could have been made so that the slight irregularities of the surfaces and joints would not be apparent. In contrast with this example is the wall similarly treated in Fig. 2, in which the blocks are made small and the imperfections are thus reduced to a negligible quantity. In addition to making the blocks small, the edges of the blocks are beveled. This treatment also tends to conceal any imperfections in the joints due to warping. This style of design is not recommended for large surfaces as it is adaptable only for designs using a tile or diaper effect.

Fig. 3 shows a building with a terra-cotta façade having

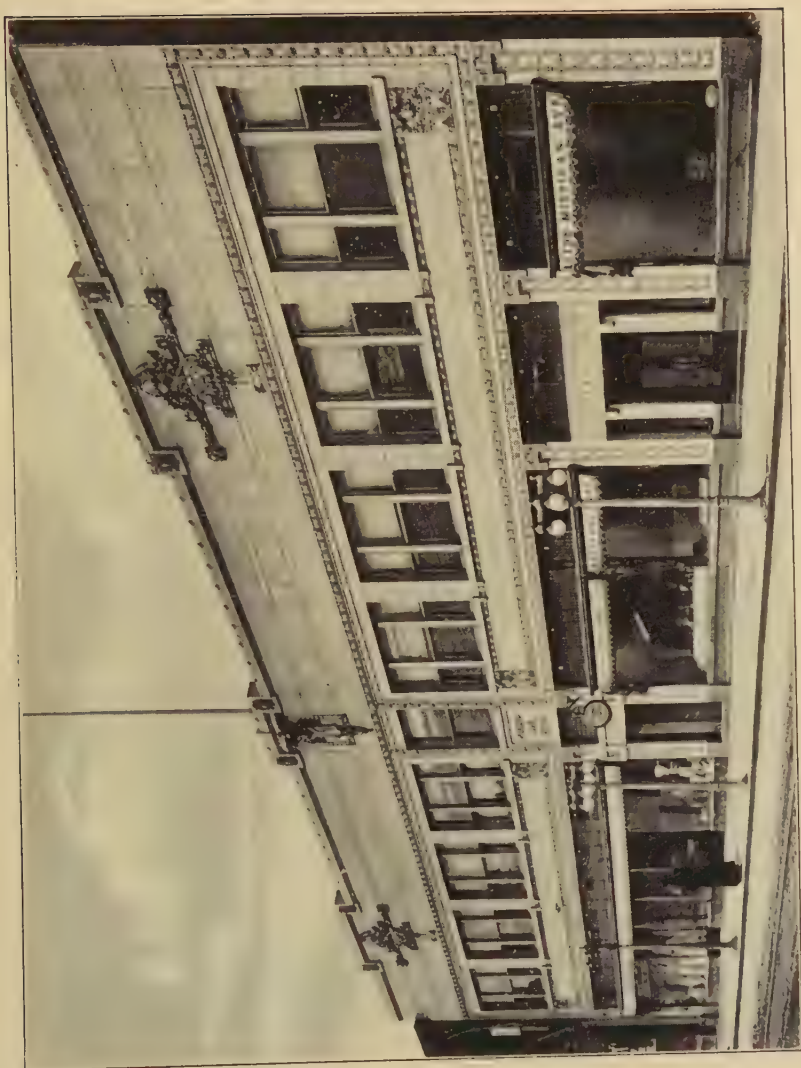


FIG. 1

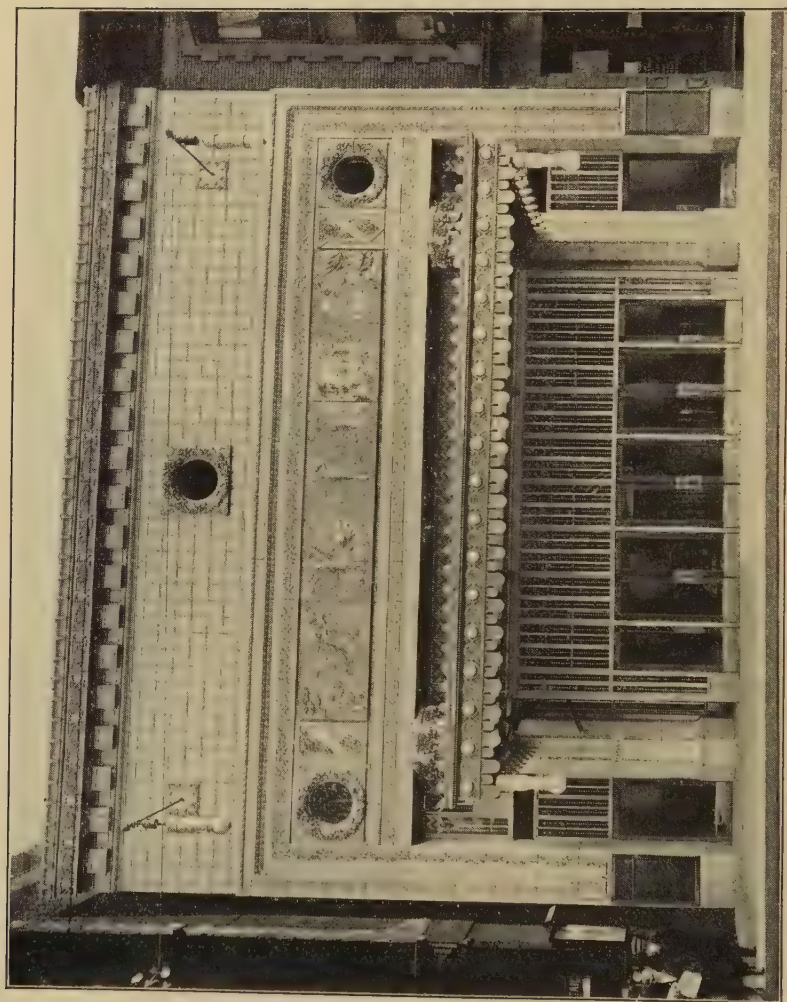


FIG. 2

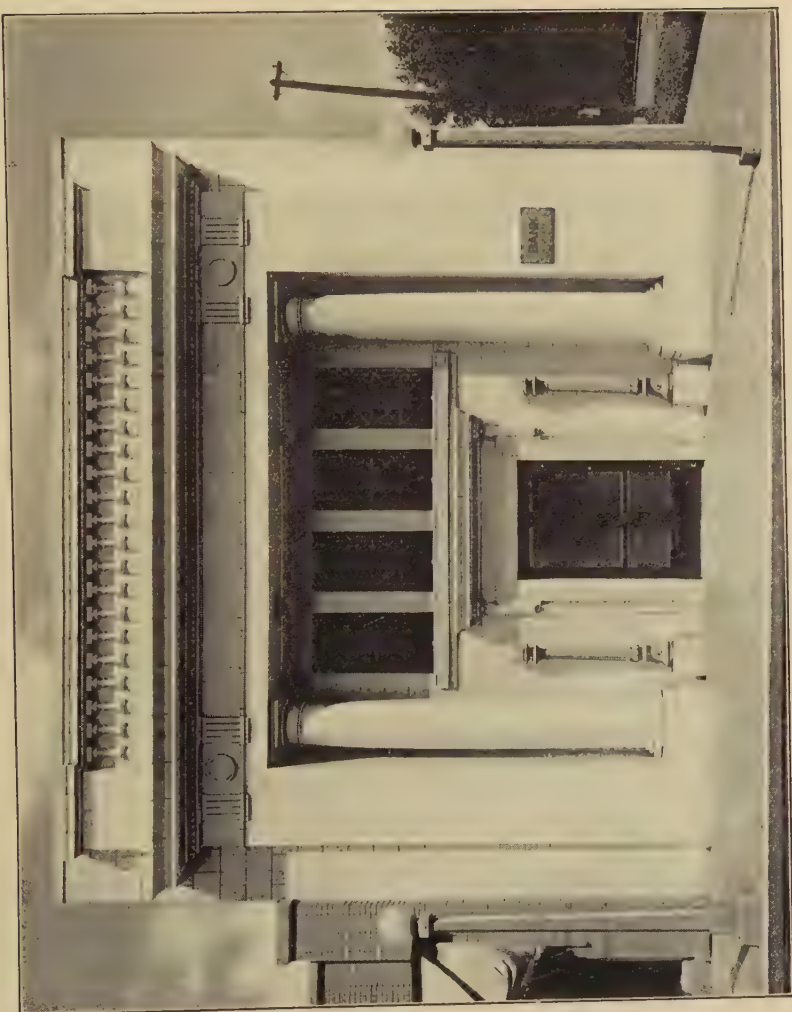


FIG. 3

plain stone-like surfaces which, while excellent, show slight irregularities in this case although they are excellent for terra-cotta work.

MODELING TERRA COTTA

16. Fig. 2 not only shows a proper treatment of terra cotta in plain blocks but illustrates the superior appearance of the terra cotta when richly decorated. It will be noted that there is a considerable repetition of blocks of the same pattern, which would be extremely costly if worked in stone. This example illustrates the possibilities of ornamentation in terra-cotta work in several ways. Shallow modeling, or *low relief* work, is shown in the borders and band courses. Bold modeling, or *high relief*, is illustrated in the wreaths around the circular windows and in the capitals of the polygonal piers. An excellent illustration of figure modeling is shown in the panel of dancing figures above the main entrance. This building is a very good example of the intelligent use of terra cotta.

17. Repetition of Ornament.—It is economical in the use of any plastic material, such as clay, to use the same ornament or motif repeatedly in the design, as this tends not only toward harmony of design, which might be too complicated otherwise, but also toward economy in manufacture. As every piece of terra cotta employed in a building must be formed in a mold, the fewer molds that are required the less will be the cost of the work. As the number of pieces needed in even a small structure often runs into the hundreds, and on larger buildings into the thousands, it can be readily seen that a large number of molds greatly increases the expense of manufacture. By repeating patterns, the same plaster mold can be used to cast from 25 to 40 blocks of the same design, which greatly reduces the cost of manufacture.

Designers should, therefore, see to it that they make their designs economical by using a repetition of patterns as much as possible. Thus, a simple running cornice in which each block is like its neighbor on either side, is less expensive to produce than a cornice composed of blocks of several different patterns.

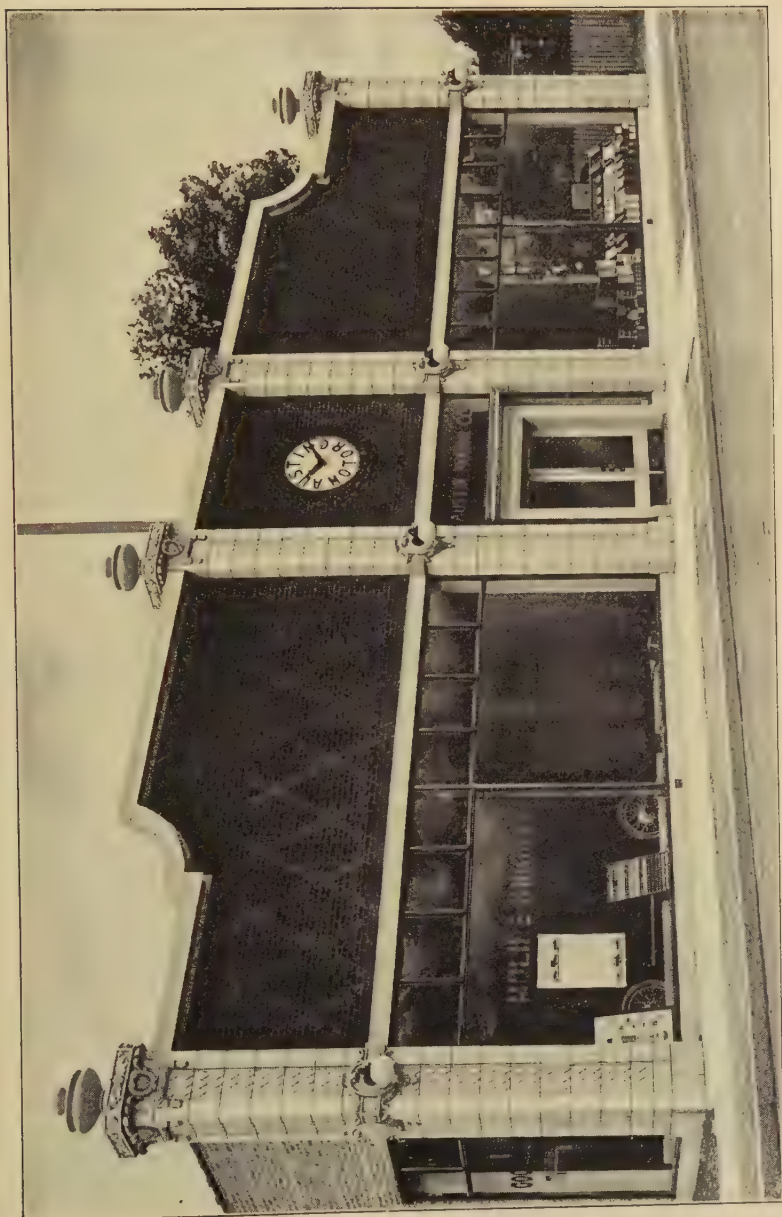


FIG. 4



FIG. 5

Lintels and sills for windows, if all of the same pattern, can be produced with a minimum number of molds, but if the lintels on each story vary, or if the several parts of each lintel are different, the number of molds required will be very large.

18. Modeling in High Relief.—Terra cotta can be modeled in high relief; that is, the ornament can be made so as to project boldly, as illustrated in Fig. 1, where an eagle in high relief is shown in the panel at the middle of the building above the windows. Bold modeling is also shown in the caps of the terra-cotta piers in Fig. 4, as well as in the ornament over the cornice of the door in Fig. 5. In fact, any projection that can be carved in stone can practically be made in terra cotta.

19. Limitations in Size of Blocks.—Stone can be used in large units, its size being determined only by the practicable size in which it can be quarried, worked in machines, shipped, and erected in place. Thus even huge columns of stone may be *monolithic*, or of a single piece of stone. Terra cotta, however, cannot economically be molded in very large units. There are several reasons for this. When undergoing the drying operation in the dry room, shrinkage in large pieces would be so much more than it is in small units that the blocks would tend to warp and crack. After drying, uniform burning in the kilns becomes very much more difficult with large blocks than with small ones and the warping is greatly increased because the heat does not attack all surfaces evenly. The handling and shipping of large blocks requires much more care than when smaller units are employed and there is much more waste from broken blocks. Hence the cost is greatly increased. It is not economical to use blocks greater in size than 27 in.×24 in.×36 in. Blocks, especially thin facing or veneering blocks, are made much smaller than this size, as the smaller blocks are usually more economical to manufacture.

20. Practical Sizes of Blocks.—As a guide to the architect when designing terra-cotta work, Table I is given to show the most practical sizes of blocks to use for some of the principal parts of a building. In the table, the dimensions given in

the column headed *Depth into Wall* include not only the depth that the block extends into the wall but the amount it projects beyond the face of the wall. Thus, a cornice that extends 10 inches from the wall should extend about the same distance

TABLE I
PRACTICAL SIZES FOR TERRA-COTTA BLOCKS

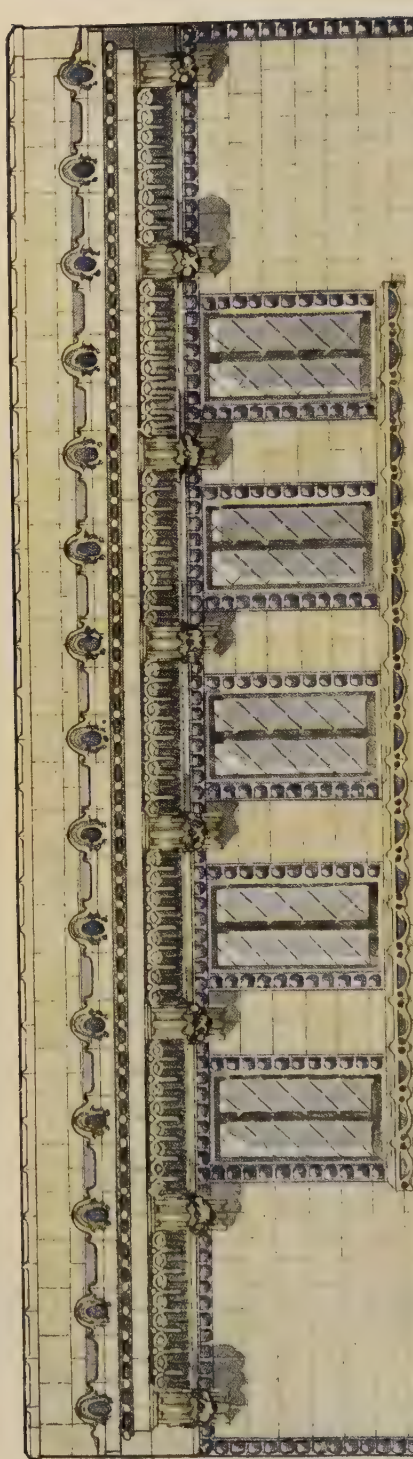
Members	Height Inches	Width Inches	Depth into Wall Inches
Cornices and string-courses.	10 to 24	18 to 24	12 to 24
Walls or panels.....	4 to 24	12 to 24	4 to 18
Sills and lintels.....	4 to 12	14 to 24	4 to 20
Jambs	14 to 24	4 to 12	4 to 12
Column drums.....	10 to 16		10 to 20 in Diameter
Columns, Segmental	10 to 16		10 to 24 Radius

into the wall, and its *Depth into Wall* dimension would be 20 inches. This applies generally, except when the terra cotta is supported by steel work attached to the frame of a building, when the blocks may extend only 4 inches into the wall.

COLORING TERRA COTTA

21. Some of the most interesting designs in modern terra cotta are in colors, such as blues, greens, yellows, browns, and reds. Polychrome terra cotta in such designs is largely used for churches, office buildings, store fronts, theaters, and interior decorations; in fact, wherever the design itself is susceptible to the proper use of color. Usually the background of terra cotta is kept in one tone and the modeled portions of the design are in variegated colors. Hence, the latter stand out from the background, and many rich and beautiful effects are obtained.

In Fig. 6 is shown a good example of the use of polychrome terra cotta. In this case it is used for a theater front. The one-tone background consists of plain-surfaced pieces in a cream color and the modeled portions are in blue, green, and brown. The large panel immediately over the entrance to the building



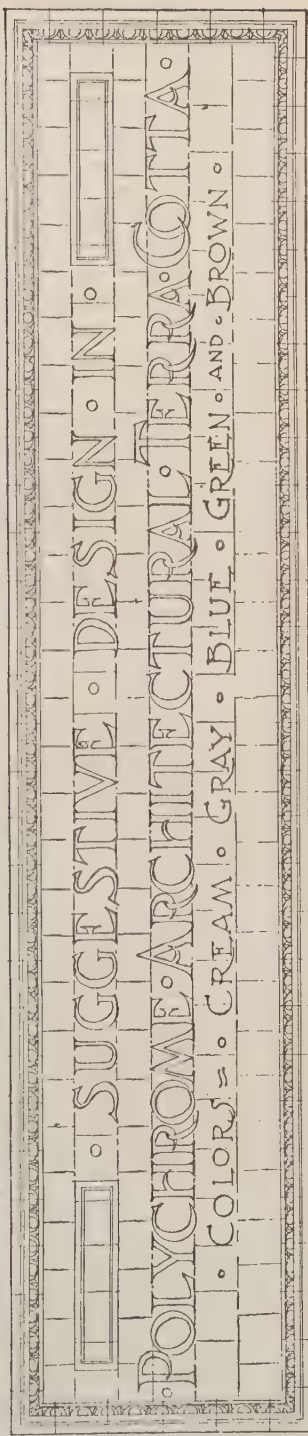
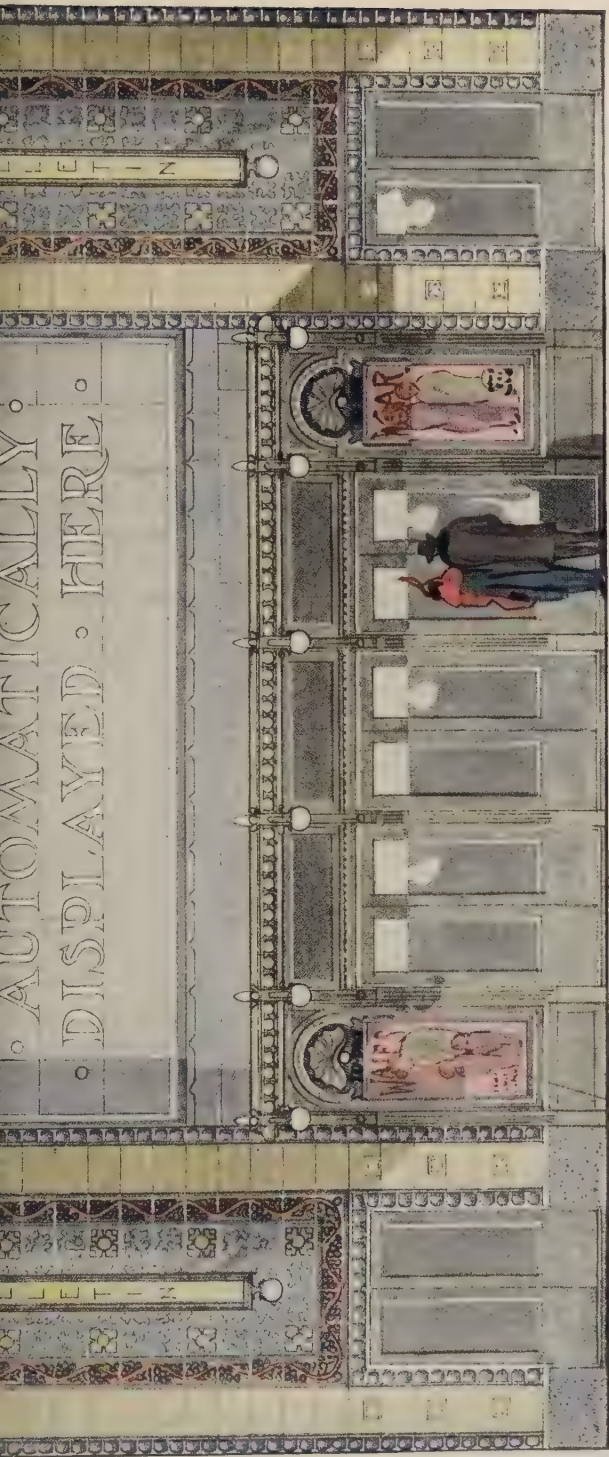
ELECTRIC

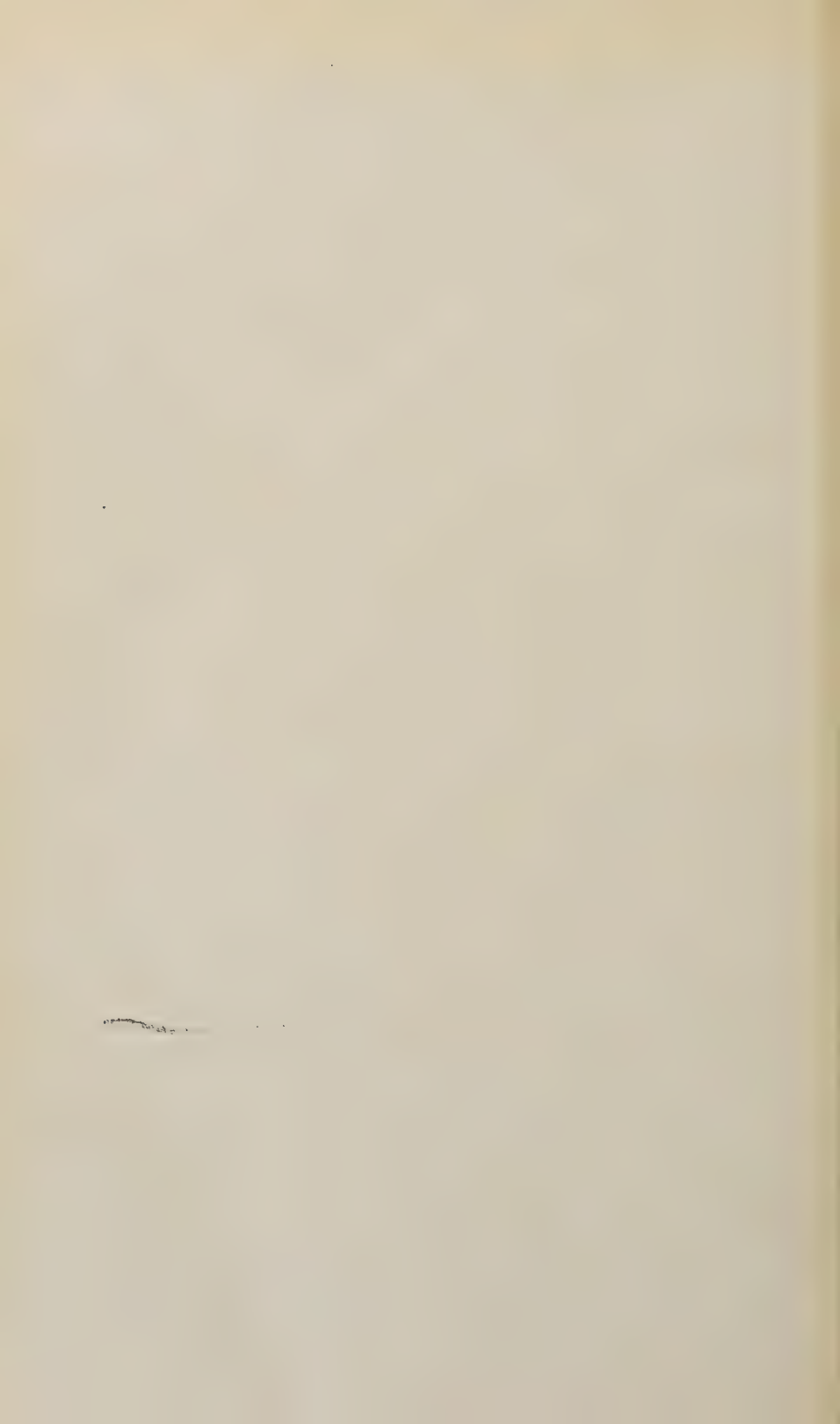
ELECTRIC

HARMONY

ELECTRIC

This block contains the right side of the page, featuring a decorative border with repeating floral and geometric motifs. In the center, the word "HARMONY" is written in a large, stylized, serif font. Above and below "HARMONY" are the words "ELECTRIC" in a smaller, simpler font. The entire text is enclosed within a decorative frame.





is also formed of plain pieces, in a gray color. This panel is intended for an advertising sign which may be applied to its surface.

DESIGNING TO RESEMBLE OTHER MATERIALS

22. Architectural terra cotta is frequently designed to resemble other materials, such as stones of different kinds, and with various finishes. Granite, with its mottled or speckled coloring, limestone and sandstone with the various toolings of the surfaces, can be closely copied. The cost of the terra cotta is generally less than the cost of the stone. Terra cotta is frequently used in conjunction with stone on the same building, the walls and plain surfaces being finished in the stone, and the ornamental parts, such as cornices and the more richly decorated portions, being formed of terra cotta. When new, the difference in the materials can hardly be distinguished, but after a time the effect of the weather often causes a decided difference in the appearance. In using terra cotta to resemble another material the designer should never lose sight of the limitations of terra cotta.

23. Terra cotta that is designed to resemble some other material, such as granite or Bedford limestone, should have the forms of the blocks and the joints as like as possible to those generally employed for the material it is to be like, otherwise the effect it is desired to obtain may be lost.

To follow out this idea, quoins and rustications are sometimes used, arches with keystones may be employed over openings, and often pilasters and panels are used. In a façade intended to resemble cut stonework the greater number of vertical joints required by terra cotta, because of the small size of the blocks, tends to spoil the effect, but a little careful planning will make it possible to put many of the vertical joints in angles where they will not be noticeable.

24. In Fig. 5 is shown a building entrance made of terra cotta formed to resemble granite. This entrance is designed with both plain and ornamented parts. The lower members adjoining the doorway, which in the illustration show darker

than the remaining portions, are finished with a glossy surface called *full glaze* and the other portions are finished with a less glossy surface called *mat glaze*. These terms are defined more fully later in this Section. It will be noted in this illustration that the blocks of the upper part of the doorway are small in size, as indicated by the numerous joints, while no joints are visible in the lower members. This is due to the lower members being made in long narrow pieces and the joints being formed vertically in the design, where they are not noticeable. This gives this lower part the appearance of being formed of large pieces of granite, which adds very much to the attractiveness of the design.

25. In Fig. 3 is shown a building which has the entire front faced with terra cotta designed to obtain the effect of light-colored stone or white marble. The panel above the cornice, which forms the background for the balusters, is formed of small pieces. By locating the joints behind the balusters, the sizes of the blocks are not apparent, and the effect produced is that of the panel being formed of one large slab.

The columns of this building are formed of small pieces. If they were to be of stone, they would either be in large pieces or in a single piece for the entire shaft of the column. The entire front is formed of pieces of terra cotta that are, as nearly as possible, of the sizes and form that would be used were the material stone, thus carrying out the principle stated in Art. 23.

26. Figs. 7, 8, and 9 all show the use of terra cotta in the construction and decoration of buildings of different types. In Fig. 7 is shown a handsome country residence in which terra cotta is used in place of stone for all the trimmings. The terra cotta is treated in a more ornamental manner than stone would be. The similarity of design in many of the parts is evident in the panels under the windows, over the entrance projection and over the porch. The square panels above the windows over the porch and over the entrance are of two patterns and are cast from two molds. The short pilasters around the top of the wall above the porch and the entrance are all of



FIG. 7



FIG. 8

the same pattern and made with one mold. Thus a very elaborate ornamentation is obtained by the use of three molds from which a great number of similar pieces have been made.



FIG. 9

27. An apartment building is shown in Fig. 8 which illustrates a profuse ornamentation made of terra cotta. The

basement walls are of plain terra cotta resembling stone, while the trimmings of the doors and windows are of molded and ornamented terra cotta used in the same manner as stone is used. The profuseness of the ornament is characteristic of terra cotta.

28. The building shown in Fig. 9 has the first-story walls faced with terra cotta designed like rusticated stonework. The balcony at the second-floor level has the design formed with plain blocks, and the brackets that support the balcony are very ornamental. The cornice and the members that surround the windows of the upper stories are all of a design that would be consistent were stone used for this purpose.

29. In all of these figures is shown the repeated use of similarly formed blocks both for plain and ornamented parts. Were the material stone, the ornamental parts of the design in many cases would not be attainable on account of the excessive cost in executing the designs in this material.

STOCK DESIGNS

30. Most of the terra cotta used for buildings is especially designed by the architect and is made to order. As the process of manufacture requires from six to eight weeks after the approval of the drawings and details, the architect often finds it desirable to use stock designs that can be obtained quickly and which often suffice for small structures. Most manufacturers keep a stock of molds for certain designs. The use of these stock molds reduces the cost of manufacture materially and also shortens the time required to make the terra cotta.

The designs that the manufacturers keep in stock necessarily consist of the more ordinary forms, for no manufacturer could afford to manufacture and carry a very extensive variety of patterns not knowing what the market demand might be.

For use in brick buildings, manufacturers also carry a line of stock designs for terra-cotta inserts, such as small ornamental blocks and small panels that can be readily inserted in face brickwork to produce an ornamental design.

Architects who contemplate using stock designs of terra cotta can obtain catalogs from manufacturers showing what patterns they carry in stock and giving the colors, finishes, and dimensions. The building in which it is proposed to use such patterns must, of course, be designed to fit the stock form of blocks, for the blocks cannot be cut and must be used in the size and shape in which they are manufactured.

An illustration of the use of stock patterns of terra cotta for a building front is shown in Fig. 1. The members which form each ornamental band or belt-course, also the panels of the pilasters, are small units of the same design, and plain pieces of terra cotta are used in various sizes to secure the required spaces for the ornamental parts. The coping is formed of both plain and ornamented pieces and is raised at intervals by means of special pieces to suit the requirements of the large ornaments that are placed over the second-story windows.

The panels over the first-story entrances, which contain the lettering, require to be made to order.

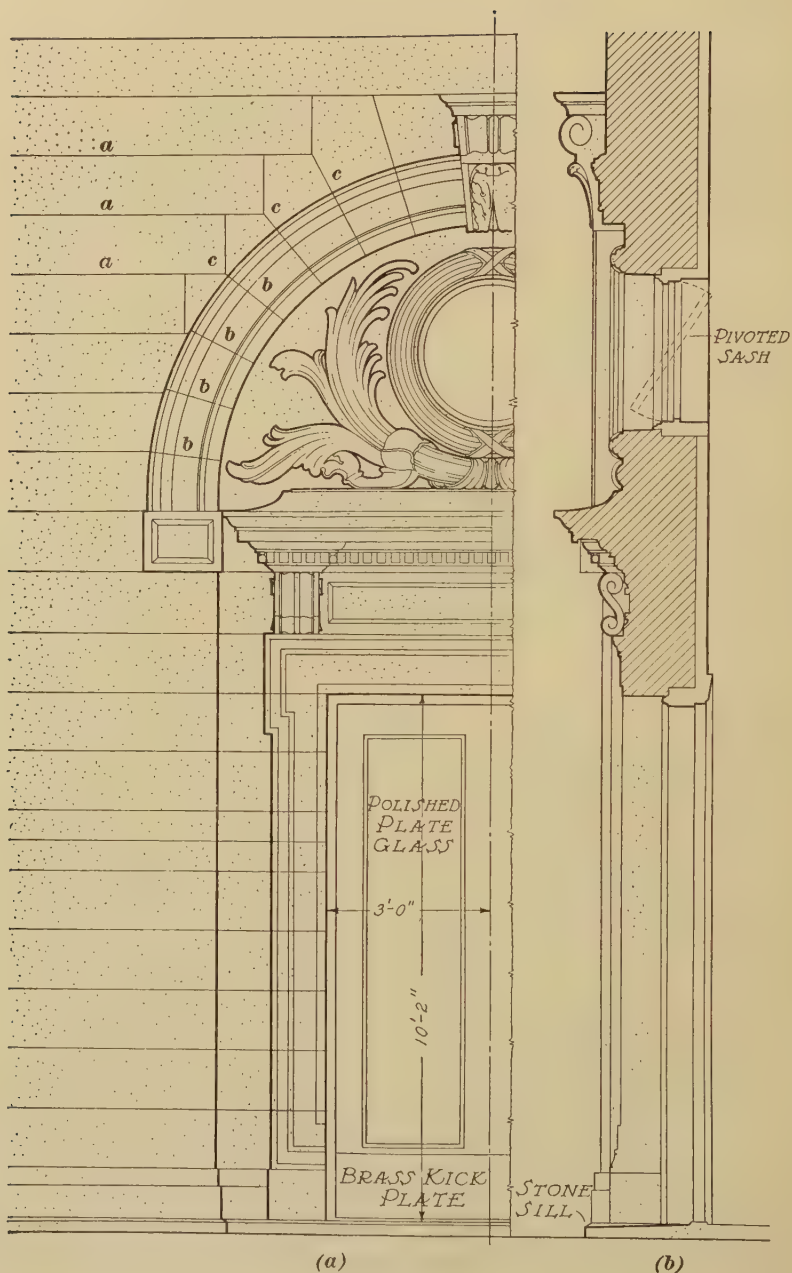
STRENGTH AND WEIGHT OF TERRA COTTA

31. Well-burned terra cotta will stand a compression test of 5,000 pounds per square inch, which is ample for any loads that are likely to be placed upon it.

The **weight** of hollow terra-cotta blocks, unfilled, is from 65 to 85 pounds per cubic foot. When filled with brick they weigh from 120 to 130 pounds per cubic foot, and when filled with concrete, from 130 to 140 pounds.

ARCHITECT'S DRAWINGS

32. The architect's drawings are made to show the design of the building which the architect has conceived and which he wishes to erect. They also are made to express the requirements of the design in such a manner that the contractor and the workmen may comprehend the intentions of the architect, provide the necessary materials and labor, and erect a structure of the form and design required.



(a)
FIG. 10

(b)

The architect's original working drawings usually consist of plans, elevations, and sections, drawn to a scale of $\frac{1}{4}$ inch or $\frac{1}{8}$ inch to the foot. These should clearly indicate the various materials that are to be used and the general form of construction. If terra cotta is to be used, the drawings should show the parts that are intended to be plain, those that are to be ornamented, and the general supports on which the terra cotta is to rest. These drawings will be sufficient for the manufacturer to bid from.

After the contract for the terra cotta has been awarded, the architect should prepare large-scale drawings that will show fully the forms of the terra-cotta parts and will give suggestions as to the jointing. He may if he desires prepare full-size details that will show the contour of all moldings, as well as the nature of the ornamental parts. These drawings are then given to the manufacturer to follow when making his shop drawings. It is customary, however, for the architect to require the terra cotta manufacturer to make the full sizes in which case they are drawn to shrinkage scale.

33. Example of an Architect's Drawing.—An example of an architect's drawing for an entrance and wall finished in terra cotta is shown in Fig. 10. Such a drawing is generally made to a scale of $\frac{3}{4}$ inch=1 foot. An elevation of part of the entrance is shown in (a) and a section through the entrance in (b). At *a* in (a) are shown the architect's suggestions for the horizontal jointing of the wall blocks; at *b*, the jointing for the arch over the entrance; and at *c*, the jointing for the terra cotta in the wall where it intersects with the arch. The jointing of the ornamental panel over the entrance is not shown in this drawing, as it is left to the manufacturer to determine what forms of blocks he can cast that will conceal the joints as much as possible.

MANUFACTURER'S DRAWINGS

34. The architect's drawings are sent to the manufacturer of the terra cotta, who copies them and adds details of jointing and of anchoring the blocks to the constructional parts of the building. These drawings are then submitted to the architect for approval. The architect makes any changes and corrections on them that his judgment may dictate, marks them *Approved*, and returns them to the manufacturer. The manufacturer then proceeds to make further detail drawings which are drawn to what is called the *shrinkage scale* as will be described presently.

35. Example of a Manufacturer's Drawing.—In Fig. 11 is shown the manufacturer's drawing of the same entrance that was shown in Fig. 10. It will be noted that the horizontal joints of the plain wall, the radiating joints of the arch, and the joints *c* between the wall and the arch, as shown in Fig. 10 (*a*), have been retained. Vertical joints *d*, Fig. 11 (*a*), however, have been added to show the length of the wall blocks. The joints *e* and *f* are suggested for the ornament over the entrance. These joints are made to follow the form of the ornament as far as possible so that they may be partly concealed.

In Fig. 11 (*b*) is shown the contour of the terra-cotta blocks that occur in this section, the depths that these blocks set into the wall, and the manner in which they are secured or supported. All of the terra cotta over the doorway, also the masonry with which it is backed up, is supported by the steel members shown at *a* and *b*. Anchors *c* are used to tie the projecting blocks to the body of the wall. The blocks *d* are designed to form a self-sustaining arch, as shown at *g* in (*a*). To prevent any settlement of these blocks or the opening of the joints between them, they are usually anchored to the steel members by means of small suspension rods, shown at *f* in (*b*). The blocks *e* in (*b*) are likewise suspended from the steel member *a*. The diagonal lines show the backing which consists of brickwork.

In addition to the general dimensions, the manufacturer's drawings usually indicate the sizes of the blocks, as in Fig. 11. When these scale drawings have been approved by the architect, the manufacturer proceeds to lay out the details of the various blocks at the *shrinkage* scale, which is a scale that makes allowance for the shrinkage that invariably occurs when burning the blocks.

36. Shrinkage of Terra Cotta.—Since terra cotta shrinks in manufacture about 1 inch per foot, the full-size shop drawings are drawn larger than the required size of the completed blocks. Thus, when it is desired to make a block

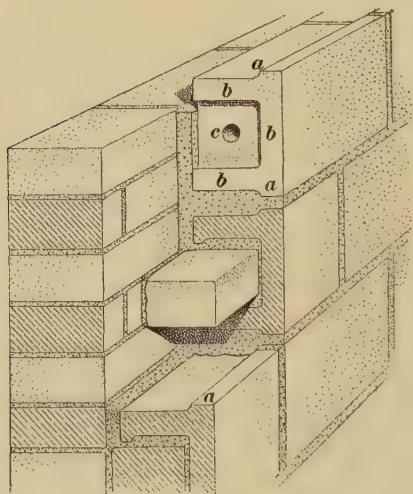


FIG. 12

12 inches long, the shop drawings show it 13 inches long. The plaster model and resulting plaster cast will be 13 instead of 12 inches long and the pressed-clay block will be 13 instead of 12 inches long. After the block has been dried and burned, however, it will be found to have shrunk to about 12 inches, or the size required.

Shrinkage can be estimated quite accurately, but it sometimes varies as much as $\frac{1}{8}$ to $\frac{1}{4}$ inch per

foot. Thus, a block estimated to shrink to an even 12 inches might prove to be when burned, $\frac{1}{4}$ to $\frac{1}{8}$ of an inch longer or shorter when it comes from the kiln. For this reason terra-cotta blocks are cast with a lug at each edge, which can be cut or rubbed down by machinery to make the block the exact size required.

The form of lug that is usually cast on the upper and the lower edges of the blocks is shown at *a* in Fig. 12. At the

ends of the blocks a similar form of lug is cast, as shown at *b*, and this projects beyond the face of the shell of the block *c*.

Variation in shrinkage is affected by the moisture or the stiffness of the clay when pressed into the mold, and by the dryness of the plaster mold in which the clay is pressed, since a dry mold will absorb more moisture from the clay than a moist mold. It is also modified by the exactness with which the clay ingredients are mixed, by the atmospheric conditions while the block is drying, and by the varying degrees of heat in different parts of the same kiln.

37. Design of Steel Supports, Anchors, Etc.—All the loose steel and iron necessary to attach, or anchor, the terra cotta to the building proper, must be designed by the terra-cotta manufacturer and shown on the drawings. He should also provide a schedule, or list, of all this iron and steel with his final drawings. Sometimes the contract requires that the terra-cotta manufacturer provide all this steel work, but as a rule the steel contractor provides it according to the schedule and drawings prepared by the terra-cotta manufacturer.

38. Final Approval of Manufacturer's Drawings. When the manufacturer's shop drawings are completed, they should be carefully reviewed by the architect to see that the designs conform in every way with his details from which the shop drawings were made. These shop drawings should show the full sizes of all moldings, the general construction of the terra cotta, and the proposed methods of anchoring the blocks to the building. The jointing also should be indicated.

It may be necessary for the shop drawings to be changed a number of times before they meet with the approval of the architect in all particulars. He should carefully review the final drawings and approve them before they are handed back to the manufacturers.

MODELING

39. When the architect has approved the drawings and has marked them accordingly, the work of modeling the various blocks is then begun. The plain work in which no molding or ornament appears is given to the average workman. Those parts of the work that consist of ornamented moldings, panels, cornices, brackets, and sculptural details are given to modelers of ability, whose duty it is to interpret the drawings in an artistic manner. Large manufacturers of terra cotta appreciate the importance of good models and usually employ only the most skilful men for this branch of the work. The results are that terra-cotta work can be used where fine artistic work is required and that this material is not considered as a mere substitute for stone, but as a material capable of the finest artistic expression when used in accordance with its peculiar characteristics.

40. Models.—Models are made for all ornamental pieces of terra cotta. These models are made of plaster of Paris, which forms the background, and moldings and the ornament are modeled in clay on the plaster backing. They are always made according to the shrinkage scale, that is, each 13 inches represents 12 inches in the finished product. The models of large pieces of ornament, panels, etc. are made without joints. The joints are put in later after the model has been finished and is ready to be cut up into blocks of convenient size.

41. Inspection by the Architect.—When the models are completed according to the drawings, the architect is notified; and if it is not convenient for him to call at the works and inspect the models, photographs are taken, a rule being laid alongside of each model to show the size and scale, and these photographs sent to the architect for inspection and approval. When this method is followed, two copies of the photograph of each model are usually sent to the architect, who indicates the suggested corrections and changes on each copy, returning one copy to the manufacturer and retaining the other copy for

the purpose of comparison with a later photograph which is sent him after his suggestions have been incorporated in the model. If the later photograph indicates that the model is satisfactory, he notifies the manufacturer accordingly.

If the architect can visit the plant to inspect the models for the terra cotta, it will prove more satisfactory than to attempt to judge and approve the models from photographs, as he can better appreciate the form, size, and details of his design by seeing them executed at full size in clay. He can also suggest changes that he may wish to make and have these incorporated in the clay and thus secure the desired effect. This done, he can approve the model and work can progress without further delay.

42. Cutting Up the Model.—After the model has been approved, it is cut into pieces of the right size from which to make the molds. The manufacturer usually determines the form and size of blocks that he considers best adapted to the design and to secure the best results in the burning. The jointing is indicated on the model or on the photograph that is submitted to the architect for his approval. Thus, an ornamental panel that may be 8 or 10 feet in diameter and in a single piece when inspected by the architect, might afterwards be cut into pieces not greater than 18 by 24 inches in size. The finished terra cotta comprising this panel will be cast in small blocks and combined to form the completed panel, all joints being filled with mortar.

If the joints are to be inconspicuous, the fact should be made known to the manufacturer before the model is cut into pieces, so that the joints may be cut around the ornaments, or that other steps may be taken to prevent the joints from showing when the different panels are built up.

MOLDS

43. Plaster Molds.—To reproduce in terra cotta the design that has been formed in the model, it is necessary to make a plaster-of-Paris mold of the model and use it as a mold into which the plastic clay is placed.

The plaster-of-Paris mold requires to be strongly constructed to withstand the pressure of the moist clay. It is usually reinforced with $\frac{1}{4}$ -inch square steel rods and the sides are bound with steel strap irons.

After the clay block has been formed, it is allowed to remain in the mold a sufficient length of time to dry properly before being removed. When it is removed it has the same contour and ornament as the original clay or plaster model.

MANUFACTURE OF TERRA COTTA

MATERIALS

44. Architectural terra cotta is made in somewhat the same manner as hollow tile or brick; that is, it is a material molded in clay and afterwards burned in a kiln. The manufacture of architectural terra cotta, however, requires a much more refined process than the manufacture of brick or hollow tile, the method is also more complicated, and the product must be worked with a larger amount of skilled labor.

45. Clay.—Clay used for architectural terra cotta must be of a higher grade than that used for brick. Terra cotta that is to be glazed requires clay free from impurities that tend to fuse in the kiln, as this action will cause the glaze to pop, making unsightly stains, crazing, or fractures.

46. Shale.—Shale is very largely used for the manufacture of terra cotta. Clay and shale from different parts of the country acquire different colors when burnt in the kiln, some coming out with a light yellowish tint, some a deeper shade of

salmon, others light or dark buff, while some are a strong brick red.

As terra cotta is a material that may be artificially glazed, the finished color does not depend upon the natural color of the body that is secured by the burning.

47. Location of Plant.—A plant for the manufacture of terra cotta is rarely located close to the source of supply of the required clay, for usually it is more desirable to keep the factory near the supply of labor and ship the clay such distance as is necessary. Furthermore, the bank of clay sometimes runs out, or the clay changes in character to such an extent that it is not suitable for the quality of terra cotta desired.

48. Treatment of the Clay.—The clay is received at the factory and is allowed to weather, which causes it to crumble and pulverize. It is then mixed with about 30 per cent. of burned clay that has been ground fine. The mixture is then pulverized by special machinery, and afterwards mixed with water and treated in a pug mill until it becomes a smooth soft mass of material capable of being molded or cast. It can be kept in that state until required for use.

49. Manufacture of Blocks.—The prepared clay is taken to the pressing room, where it is pressed into the plaster-of-Paris molds and then artificially dried with hot air, a process that usually requires from 2 to 3 hours. By this time the material has dried and stiffened sufficiently so that the blocks can be taken from the molds and handled without injury.

The raw blocks are then finished; that is, the seams are removed and the ornament is cleaned out.

If the blocks are to be finished with a smooth glazed surface, they are troweled smooth, and in this process the pores of the clay become closed and the finished surfaces of the material are made smooth and firm to receive the glaze.

Next, the blocks are placed in dryers, where they are subjected to hot air. This expels all moisture from the blocks, gradually making them bone dry. This drying takes about 48 hours.

The blocks then go to the glazers, where the exterior, or visible, surfaces are coated with a color or glaze as desired. They are then ready for burning and are taken to the kiln and subjected to a heat of from 2,000 to 2,300 degrees F. The burning process usually lasts from 12 to 14 days.

All terra-cotta blocks are made hollow, and the outside shell, which is usually 1 inch thick, is stiffened with webs, which are also about 1 inch thick. The number, size, and thickness of the webs and the thickness of the shell are determined by the size of the blocks, large blocks requiring a thicker shell and more webs than small ones. The voids are placed about 6 inches on centers.

Webs and shells of blocks have holes cast in them to facilitate anchoring them to the wall or structure. These holes also facilitate the handling of the blocks, as it is possible to pass the fingers through the holes when carrying the blocks. At the same time holes make the blocks lighter in weight and furnish a better bond for the mortar, which can flow into them and form a key.

FINISHES AND COLORS

50. Owing to the fact that terra cotta is formed of plastic clay, any finish or texture of the surface may be obtained by treating the block when it is being formed. Like pottery and faience, the clay may also be tinted, and any color, combination or blend of colors may be secured when it is burned in a kiln.

51. Texture.—The texture of the material is obtained in three ways: (1) By reproducing the sample of the surface to be matched, by modeling it in clay in the face of the plaster model before it is molded. This method is used to reproduce picked, stippled, crandaled and bush-hammered surfaces; (2) tooled surfaces are cut in the mold by special tools; (3) smooth-, light-, and rough-drag surfaces are obtained with finishing tools after the blocks have been removed from the mold. These textures may imitate rough, smooth, tooled, or polished stonework. To produce imitation granite, limestone, or sandstone, the manufacturer uses for his model a block of

real stone and can produce an accurate imitation, either of polished or dull finish or of the texture given to the stone by means of tools or hand modeling.

52. Coating or Spotting of Terra Cotta.—In terra cotta the original mixture of clay has little influence on the final color, which is obtained by tints applied in the form of slips, or glazes. These glazes produce the plain colors such as are seen in polychrome terra cotta. The mottled finishes are obtained by spotting the surface or the slip with various colors to produce effects such as the mottled colors of granite or other stones of a spotted nature. Thus, by combining spotting and texture, endless variations are possible.

53. Glazing.—The final process of treating terra cotta before it is burned is known as *slipping* or *spraying*.

Terra-cotta plants usually maintain a laboratory where the various clays, colors, and glazes are experimented with. Mineral colors are used in coloring and glazing and these materials do not look the same after they are baked as when they are applied to the unburned block. The burning produces a chemical change in the colors. Hence when seeking new shades of color the chemist applies the coloring material to a small briquette of terra cotta, burns it, and notes the results. The formulas for all mixtures of color and glaze are carefully preserved, so that given colors can be reproduced at any time. When it is decided to use a certain color or glaze, the coloring materials are carefully weighed and mixed together in exact proportions with the greatest care according to the formula for that color. The colors are mixed with water and applied to the blocks before burning, by means of a spray from an air brush. With some glazes or where a full gloss is desired on the surface, it is sometimes necessary to put on an *under glaze* as a first coat, and apply the final glaze over this.

54. These glazes are used to furnish the colors required by the design and at the same time they make the surface of the terra cotta more or less impervious to water. There are four finishes that are usually specified by architects. These are

the *standard*, or *unglazed*, which is not wholly impervious to moisture; the *vitreous*, which is impervious to moisture; the *mat-glazed*, or *mat-enameled*, which is glazed, has a dull finish, and is impervious; and *full-glazed*, or *enameled*, which is impervious and has a glossy finish.

In addition to these standard finishes, terra cotta, as has been stated, can be treated in any desired shade or color, to form polychrome terra cotta. Different parts of the block may be treated with different colors. If not otherwise specified, most manufacturers base their estimates on the *standard color*, which is that of light Indiana limestone, and is unglazed.

55. In **standard** finish, the terra-cotta blocks, after drying and before burning, are covered with a coating of clay *slip*, applied with an air brush. This produces a dull finish which is not "glassy" and the terra cotta so treated is not impervious to moisture, but has about the texture of good hard burned face brick.

In the **vitreous** finish, the glaze, or slip, is prepared with more of a glass-like quality by the addition of suitable minerals. This is also put on with an air brush, and two coats may be necessary to obtain the color desired, the first coat being a slip of one color to fill the pores of the blocks and the second coat a glaze of the same or another tint, depending upon the effect desired.

The glaze used in the vitreous finish vitrifies when burned; consequently, terra cotta with this finish is impervious to moisture. This glaze is, however, very thin.

Mat-glazed, or **mat-enameled**, finish, as its name suggests, is a dull glazed finish in which the glaze employed is of a glass-like nature but the finished blocks are not glossy. The glaze is heavier than that used on semiglazed terra cotta. The surface of mat-glazed terra-cotta blocks is impervious, hence they are excellent for outside work where the weathering qualities of the blocks must be considered. Mat-glazed finish can be washed down as readily as full-glazed.

Full-glazed terra-cotta blocks, as their name implies, are coated with what is practically liquid glass, which when burn-

ing fuses and leaves a glossy finish excellent for its weathering qualities and because it can so readily be washed clean. This finish is, however, expensive and not frequently used.

FITTING AND NUMBERING THE BLOCKS

56. Fitting the Blocks.—After the terra-cotta blocks have been burned they are allowed to remain in the kiln until they cool. They are then taken to the storage shed and the pieces are laid out on a floor in the order in which they will appear in the finished building. The pieces are carefully fitted together to see that they are the exact size and shape called for by the shop drawings. Any pieces that are imperfect are sorted out and new pieces made to take their places.

When the blocks are laid out, every block in a string-course or cornice, lintel, or jamb is carefully placed to see that the length of the course is just right as shown on the plans. Thus, a cornice composed of many blocks of terra cotta is like one composed of cut stone, each piece of which must be carefully made from the architect's drawings so that when they are placed together and the proper allowance made for the mortar joints, the total length will meet the requirements of the drawings.

Some of the blocks may require to be cut down slightly, and to accomplish this result the lugs on either end, which are provided for this purpose, are cut with a chisel; or if the excess is very slight, as is usually the case, one or both ends of the blocks are rubbed down by machinery.

It is the usual practice to rub or cut down all adjoining edges of blocks whether any great excess of length has to be removed or not, as this treatment secures a true and square edge at the joints, consequently the lugs are formed sufficiently long to permit of this rubbing without cutting into the shell of the block.

To insure the proper inspection and jointing of the blocks by the manufacturer at the plant, however, the architect should incorporate in his specifications definite requirements regarding this work. This is desirable in order that imperfect pieces may

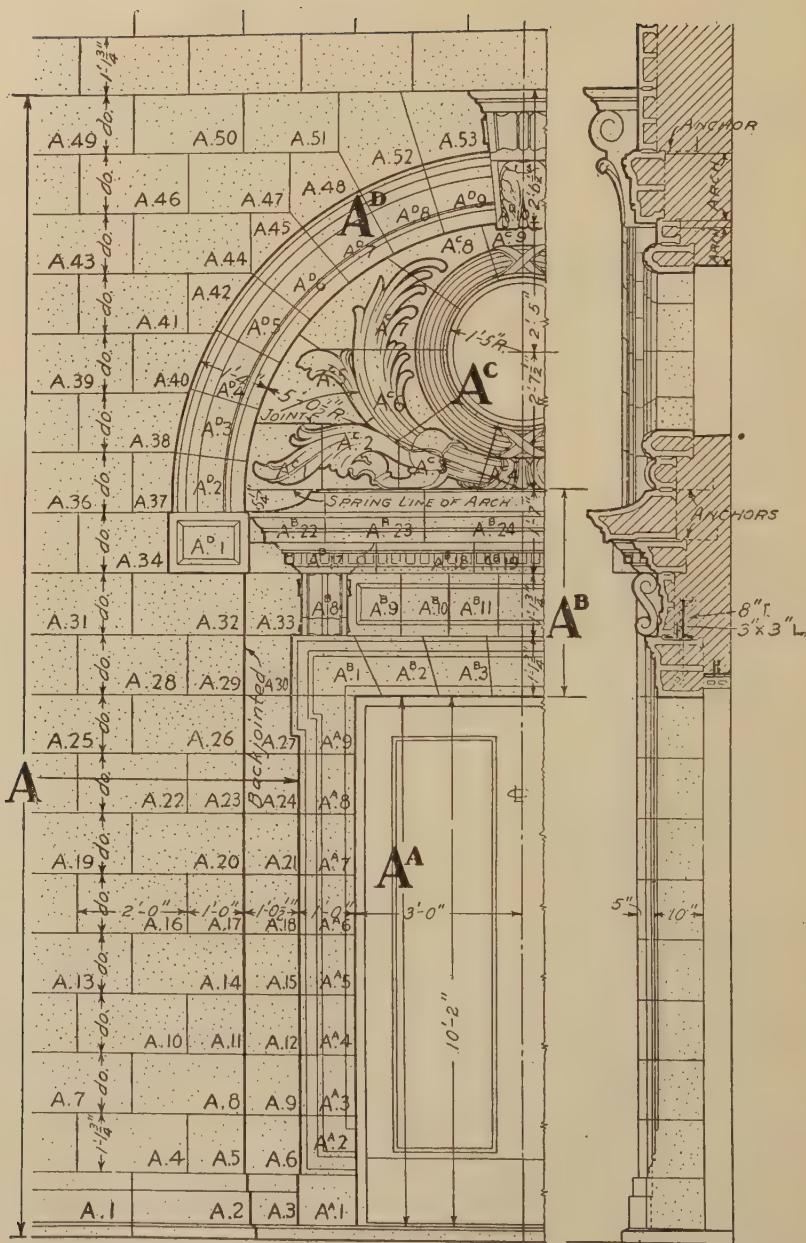


FIG. 13

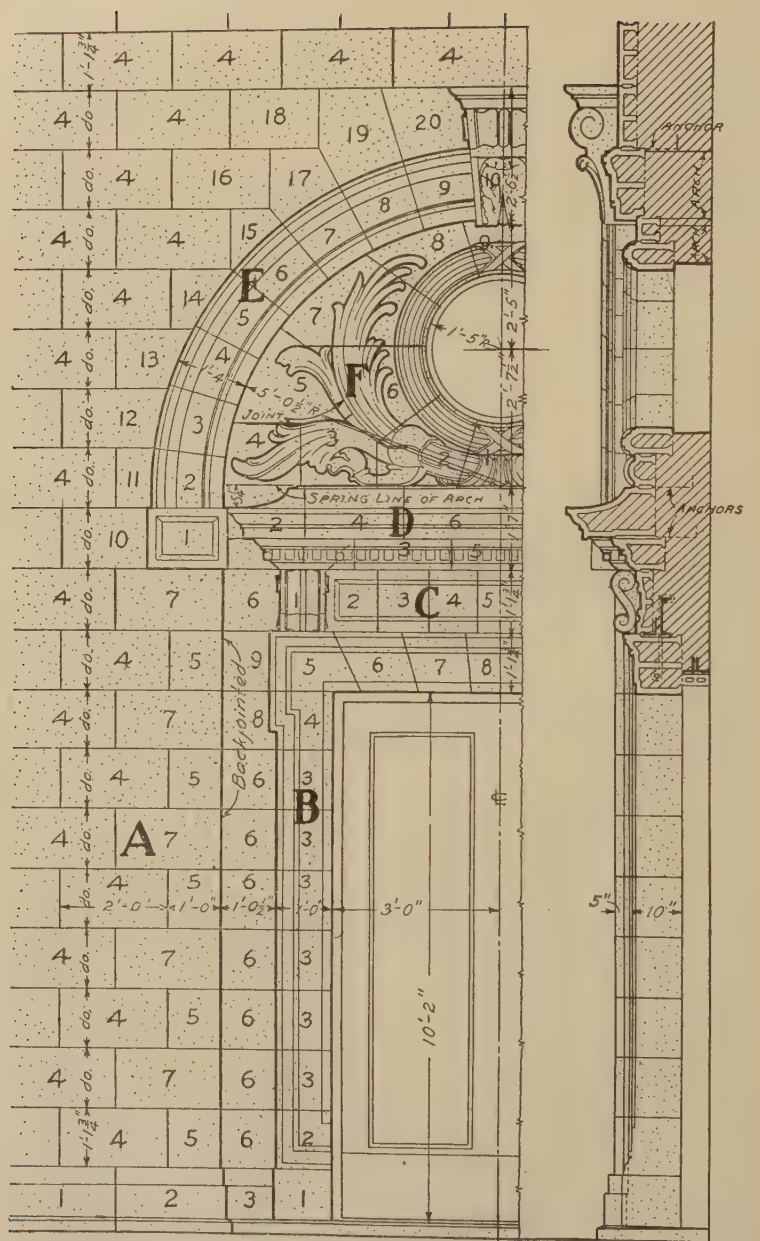
be replaced as soon as possible instead of waiting for errors to be discovered at the building, when the work will be delayed while new pieces are being made.

57. Numbering the Blocks.—After the blocks have been fitted together at the factory, each piece is marked on the back with black paint. A diagram is then made which shows each block of terra cotta, and this is marked with letters and numbers to correspond with those placed on the blocks. This diagram is sent with the shipment of terra cotta to the building so that the workmen can readily assemble the blocks in precisely the same order in which they were fitted at the factory.

This assembling diagram, sometimes called the *setting plan*, usually consists of a blueprint of the manufacturer's scale drawing on which is shown every block and all the joints. Fig. 13 is an illustration of such a plan for the terra-cotta entrance shown in Fig. 11. The terra cotta of each story is usually indicated by a large capital letter, *A* representing the first story and *B* the second story, etc. Each special feature is represented by a smaller capital letter, that, in connection with the larger capital letter and a number, is used in marking each block.

Thus, the plain wall facing for the first-story wall is labeled *A*, as indicated in Fig. 13, and each block has a special number. The arch over the entrance is marked *A^D*. All the pieces of terra cotta forming this arch are marked *A^D* and a special number, as *A^D.1*, *A^D.2*, etc. This system of marking absolutely identifies each block and, having the setting plan and the number on each block, the contractor should have no uncertainty in picking out the blocks.

58. Another system of marking the setting plan and the blocks is illustrated in Fig. 14 which has some advantages in the way of simplicity. The different features of the building are lettered *A*, *B*, etc., but by this method all similar blocks have the same number. Thus, all the wall blocks are marked *A* and all the blocks shown marked *A 5* are of the same size and pattern, and all marked *A 4* are of the same size and pattern.



Any block marked *A 4* can be taken from the pile and placed in any position marked *A 4* in the setting plan. In the system shown in Fig. 13 blocks *A 4*, *A 10*, *A 16*, *A 22*, etc. are all of the same pattern and are interchangeable, but they must be carefully sought and laid in the rotation indicated on the plan. Thus the mechanic must look after fifty or more numbers instead of eight or ten.

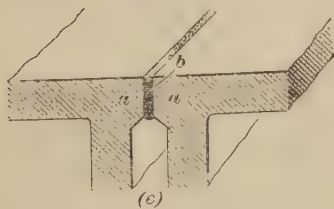
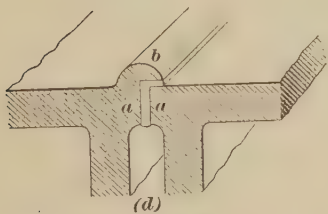
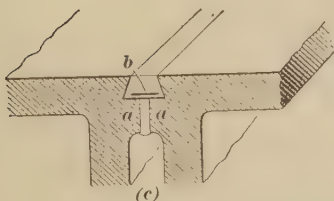
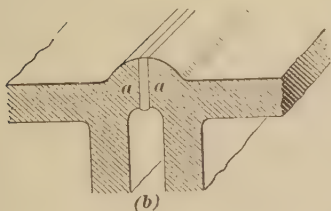
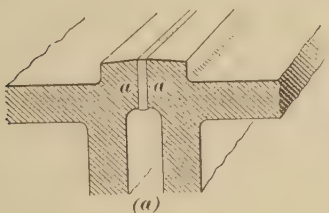


FIG. 15

DETAILS OF CONSTRUCTION

59. The process of designing terra cotta, of making the various drawings required, of modeling, and of the manufacture of the blocks having been described, some of the details of construction, which are peculiar to this material, will next be considered.

60. Forms of Joints.

The joints considered in this article are the abutting or connecting surfaces of the various blocks, and not the spaces filled with mortar between the blocks. The character of these joints is peculiar to terra cotta. The straight joint is illustrated in Fig. 12. These joints must be made so as to allow of grinding or chiseling off the joints when

the block has not shrunk to the degree calculated upon or is so

warped that trimming of the joints is necessary to make the face of the block true. As it would be difficult and expensive to grind the entire surface of the block, the joints are designed to be formed by the edges of the block, which are slightly raised so that any fitting that may be required may be done on the narrow surfaces *a*, *b*. The depressed spaces behind these narrow edges are filled with mortar.

61. Another characteristic form of joint is that required on the top surfaces of cornices, copings, string-courses, window

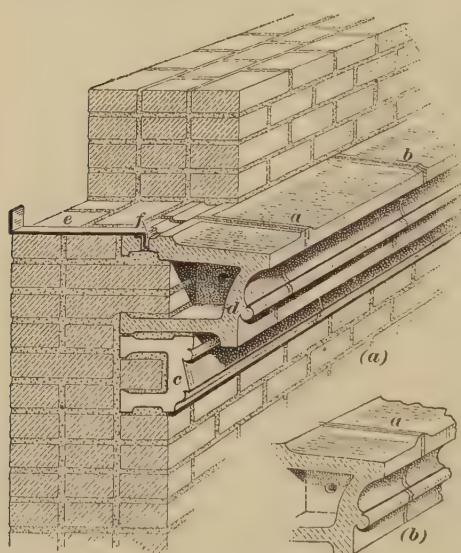


FIG. 16

sills, or any other surface upon which rain or snow may fall. These joints are illustrated in Fig. 15 (*a*), (*b*), (*c*), (*d*), and (*e*), which show five customary forms of such joints.

In (*a*) is a *rectangular raised joint* and in (*b*) a *segmental raised joint*. The raised portions prevent water flowing into the joint. Both these forms are extensively used, and, where the opening

between the blocks is well filled with mortar, prove very satisfactory.

In (*c*) is shown a *recessed, or dovetailed, form of joint*. A piece of sheet metal *b* is usually inserted to form a base on which the mortar may rest and to prevent the mortar passing through the smaller opening below. The mortar of these joints is finished flush with the surface of the block.

In (*d*) is shown the *roll joint, or covered joint*. This form of joint affords better protection to the mortar joint between

the blocks than any of the other forms described. The roll *b* is, however, often broken or injured in handling or shipping, or is forced off by the action of frost which necessitates repairs that always prove unsightly. The use of this style of joint is therefore not to be recommended.

In (*e*) is shown a *butt joint*, such as used in stone and marble work and is highly recommended for use in terra-cotta con-

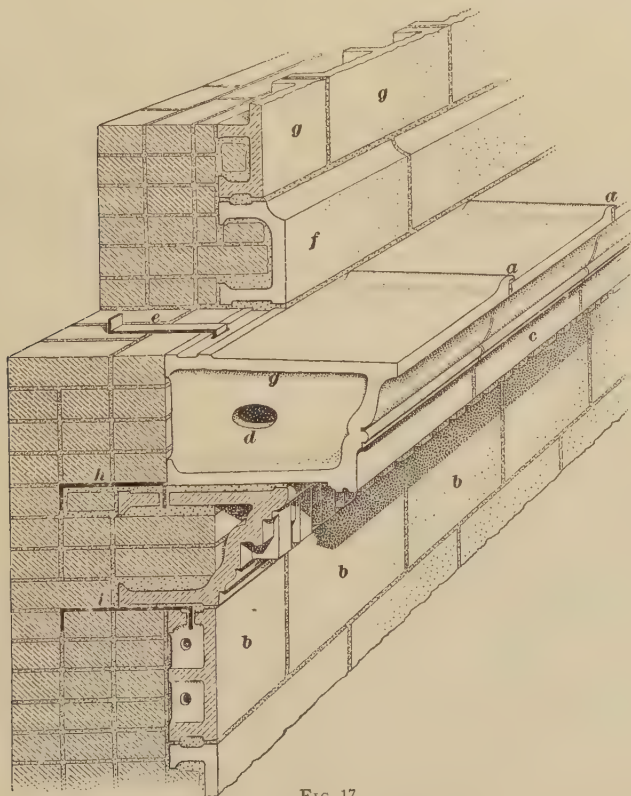


FIG. 17

struction. The edges of this joint are not easily marred by handling and the joint can be calked with mastic *b*, without necessarily breaking the edges. This style of joint is to be preferred to the others, as it presents no thin projecting parts that can be easily broken off.

62. Examples of Joints.—In Fig. 16 (a) is shown a terra-cotta belt-course that is built into a brick wall. The upper part of this course has blocks that are formed with joints of the raised rectangular shape. At *a* is shown one of these joints finished straight with the edge of the block, while at *b* the joint at the edge is finished with a *cove*. By means of this form the

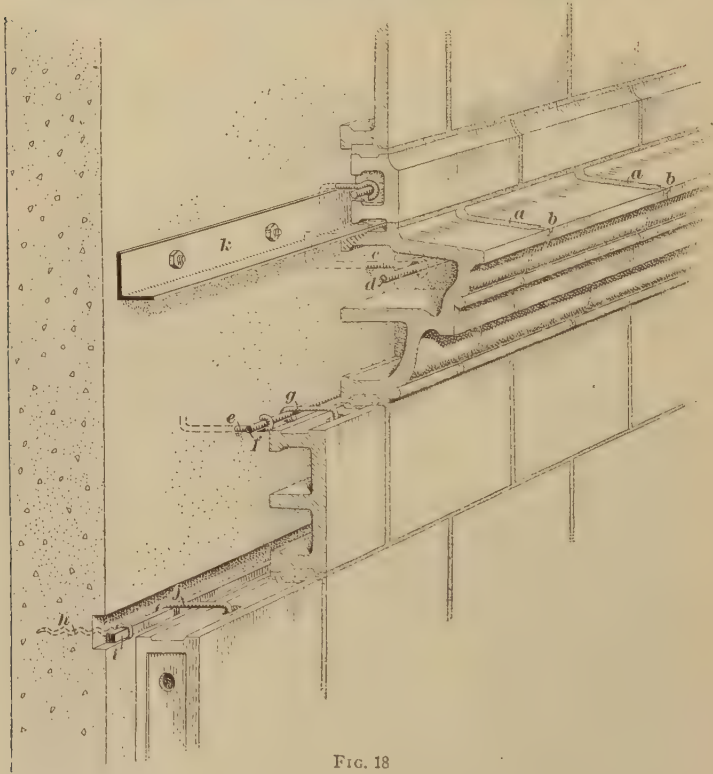


FIG. 18

joint projecting above the block is not apparent from below. At *a* in (b) is shown a segmental raised joint.

In Fig. 17 is shown a wall faced with terra cotta, and a projecting course also formed of the same material. The blocks of the projecting course have a roll, or covered, joint *a*. These joints, as well as the segmental raised joints, may terminate at the edge of the course with a cove as previously described.

In Fig. 18 are shown joints *a* of the dovetailed form. In this illustration it will be noted that at the front edge of the block, as shown at *b*, the joint is contracted to the same width as the regular vertical joint below.

63. Concealed Joints.—As the sizes of the blocks used in terra-cotta work are necessarily small, there will be a considerable number of joints. It is therefore desirable to conceal these joints when it is possible. This can often be done with vertical joints, which can be concealed at panel moldings, pilasters, window and door trims, etc. In concealing these joints, one block is rabbetted out so as to project in front of another piece, thus concealing the joint. These joints are considered as concealed as they are not visible to a person looking at the building casually.

In Fig. 19 is shown a concealed vertical joint between the blocks which form a paneled pilaster and the wall of a building. The block *a* is recessed on the back at *b* and the end of the block *c* is placed in this recess and thus made to fit closely. This method of treating joints is sometimes called *back-jointing*.

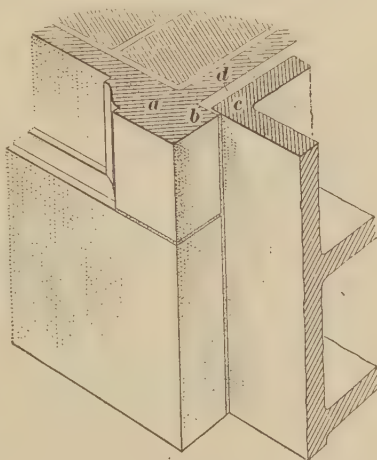


FIG. 19

Additional illustrations of concealed vertical joints appear later on in this Section in connection with the description of Columns and Pilasters.

64. Reglets.—Where a wall or a wall facing of terra cotta adjoins a roof construction, it is often necessary to place flashing and cap flashing against the terra cotta. The exact position of the roof should be shown on the plans and if it is found that the horizontal joints between the terra-cotta blocks will not serve to receive the upper edge of the cap flashing,

grooves, called *reglets*, should be formed in the terra-cotta blocks for this purpose.

In Fig. 20 is shown a parapet wall formed of the terra-cotta blocks *a* and coped with the blocks *b*. At *c* is shown a *reglet* that has been formed in the blocks adjoining the roof, and at *d*, is shown the edge of the cap flashing *e* placed in this reglet.

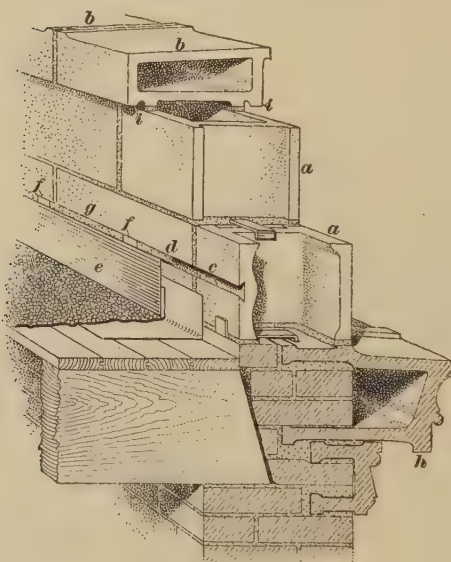


FIG. 20

secured by means of lead wedges *f* placed at intervals, and the remaining part of the reglet is filled with roofer's cement, as at *g*, to insure a waterproof joint.

65. D r i p s .

Terra-cotta sills, string-courses, cornices and copings that project beyond the face of the wall below should have a member formed on the lower part, called a *drip*, that will cause the water to fall free from the wall and not run

directly down the wall. In Fig. 20 is shown a projecting cornice with a drip at *h*, and a coping with drips at *i*.

66. Securing Terra Cotta to the Structure.—Since terra cotta is generally a veneer, it must be fastened to and supported by the general structure in some way. There are two methods of fastening terra cotta to the supporting structure: First, by bonding the blocks into the wall; and second, by fastening it to the structure by means of steel work in the form of ties, anchors, channels, angles, etc. The forms of steel used in this work are shown in connection with the various details or forms of terra-cotta work next to be considered.

67. Wall Facings.—In buildings of brick or stone masonry faced with terra cotta, the facing blocks are laid up like brick or stone, each course being embedded in mortar on the course below. Each piece is anchored with galvanized or painted iron wall ties embedded in the main wall or anchored to the steel frame to hold the terra cotta securely in place. Fig. 17 illustrates the application of a terra-cotta veneer to a brick wall, and shows the anchor *i* that holds one of the blocks in position against the wall. Most of the blocks are fastened to the wall in the same manner. The backs of the blocks are filled in solid with brickwork in cement mortar.

68. Wall Facings on Concrete Walls.—Fig. 18 shows the method of securing a terra-cotta facing to a solid concrete wall. In this construction the concrete wall is built first, and the anchor hooks, bolts, etc. are located and placed in the wooden forms in which the concrete is cast. In this system of veneering, the blocks are held in place entirely by the anchoring. It is therefore very necessary that the anchors be installed with great care.

69. Three systems of anchoring are shown in Fig. 18. In one system the hooked rod *c* is located so that it will come between the end shells of two adjoining blocks which are formed to fit accurately a horizontal round bar, as shown at *d*. This bar is sufficiently long to extend through the shells of both of the blocks and through the eye of the hooked bar. In this system, the hooked bars must be very carefully located so that they will come at these joints, otherwise they are not serviceable. In the second system of anchorage, the hooked bar *e* is turned around the horizontal bar *f*. This latter bar is located back of the blocks and the blocks are anchored at the top by pieces of iron as shown at *g*. As the bar *f* is continuous, anchors may be placed at any desired location horizontally. The vertical location of this rod must be accurately determined to insure proper connections being formed. The third system is illustrated in the lower part of the figure. At *h* is shown a heavy wire which is left projecting from the wall surface. By means of this wire, the rod *i* is attached to the wall and fits

into the recess that has been formed in the wall for this purpose. The method of anchoring the blocks to the rod *i* is shown at *j*.

70. When terra cotta is used as a veneer and cannot be filled with masonry, special precautions must be taken to avoid overloading the blocks and thus causing them to be crushed or the edges to be chipped. Where the space between the wall and the blocks permits of the pouring of concrete, this space and the blocks may be filled with a cement grout, but this work should be done as the work progresses and not after the wall has been completed to a story height.

Terra-cotta facings of the character mentioned are sometimes supported at intervals by means of angles such as shown at *k*, Fig. 18, called *shelf angles*. These are secured to the concrete structure by means of bolts which are placed in the concrete forms at the required locations before the concrete is poured, and after the forms have been removed the angles are attached to the wall by means of these bolts.

These angles must be accurately located and the lower flange should line with the horizontal joint in the terra cotta so that one course of blocks may have a direct bearing on the angle. The blocks resting on the angle should also be anchored to the angle, which is set away from the face of the building by means of washers. This permits of running wire behind the angle and securing the terra-cotta blocks in place, or of the use of bent rods such as shown in Fig. 18.

71. String-Courses.—String-courses are usually built into the wall as shown in Fig. 16. This example consists of two courses of terra cotta. The lower member *c* extends into the wall as far as the width of one brick and, since it has to support the weight of the construction above, it is filled in solid with brick and mortar. The upper course, shown at *d*, has a greater projection and also extends into the wall. Both these courses are filled with brickwork as far as the line of the wall face. The projecting part of the upper block is not so filled. Metal anchors of the form shown at *e* are used to tie the pro-

jecting blocks to the wall. The blocks have holes formed in the upper shell, as shown at *f*, to receive the anchors.

72. Cornices, Medium Size.—A medium-sized cornice is shown in Fig. 17. The wall supporting this cornice is faced with plain terra-cotta blocks *b*, equal in thickness to one thickness of brick. The cornice consists of two rows of blocks. The lower blocks are richly molded and have a considerable projection in front of the face of the wall. This course must provide a certain amount of support to the upper course and therefore must be filled with masonry and anchored to the backing by anchors such as shown at *h*. The blocks of the upper course *d* extend back into the wall so that they may have good bearings, or supports, and may be covered by the masonry above. This masonry resting upon the backs of the blocks prevents them from tipping outward. These blocks also support a considerable load of masonry, consequently must be filled with brickwork as far as the face of the wall. The projecting portion of this cornice is not filled with masonry, as it is desirable that this part be as light as possible so that it will have no tendency to drop or tip. The blocks in this course should be carefully anchored to the brick wall as shown at *e*. The course *f* projects in front of the face of the wall. Above this course the wall is faced with the blocks *g*.

73. Large Cornices.—Large projecting cornices of terra cotta usually require to be supported by the structural-steel frame or by the solid masonry walls of the building. Cornices that are designed for buildings having a steel frame usually have an interior framework of steel shapes, and this frame is connected with the frame of the building in such a manner that the entire cornice is supported by the steel work of the building. This form of construction is very complicated and the structural engineer who designs the frame of the building usually designs it so as to support the cornice properly. The terra-cotta manufacturer will then design the secondary steel members that are required for his work.

74. Cornices for solid masonry walls, such as those illustrated in Fig. 21, are usually so designed that the lower

The blocks *a* and *b* are filled with masonry and are also anchored by means of the tie-rods *g*. These blocks project beyond the wall surface and help to carry the brackets *c* and the wall blocks indicated at *f* between the brackets. The projection of the brackets *c* is so great, however, that the anchors and back filling are not sufficient to hold them in place. Steel angles *h* are therefore installed above each bracket to form a cantilever support. The angles are separated slightly to allow the rods to be placed between them for anchoring into the wall and for the suspension of the blocks. Wall anchors, one of which is shown at *i*, are provided to hold these angles in place and are usually several feet in length. Each anchor has a plate at the lower end, as shown at *j*, to anchor the rod to the wall. The upper ends of the anchors are fastened to the continuous channel *k* which runs parallel with the wall. By means of these anchors and fastenings, the steel angles are prevented from being pulled out of the wall by the weight of the cornice.

The bracket blocks *c* are supported and kept in place by a length of iron pipe *m* which is placed inside the bracket. One end rests on the brick wall and the other end is suspended from the channels by means of a rod *l*. This rod has a thread and nut on the upper portion. By turning the nut the bar *m* is raised until it comes in contact with the upper shell of the bracket and holds the bracket firmly in place. The blocks *d* are formed to fit over the angles *h* and rest on the brackets and the wall blocks between the brackets. The top members of the terra-cotta cornice, shown at *e*, rest on the blocks *d* and are anchored to the wall by rods, one of which is shown at *n*.

In (*b*) is shown a perspective of the steel work used in this system of supports with the various members assembled. The series of cantilever angles are shown at *a*, the continuous channel at *b*, and the anchorage and suspension rods as just described.

76. Lintels.—In Fig. 22 is shown an entrance to a building which has walls faced with terra cotta. The jambs and lintel of the opening are also formed of the same material. Since the terra cotta is only a veneer for the brickwork, it is necessary

that steel supports be provided to carry the terra cotta as well as the brickwork over the opening.

Fig. 23 (*a*) represents a section taken through the center of the lintel over the entrance shown in Fig. 22. The steel sup-

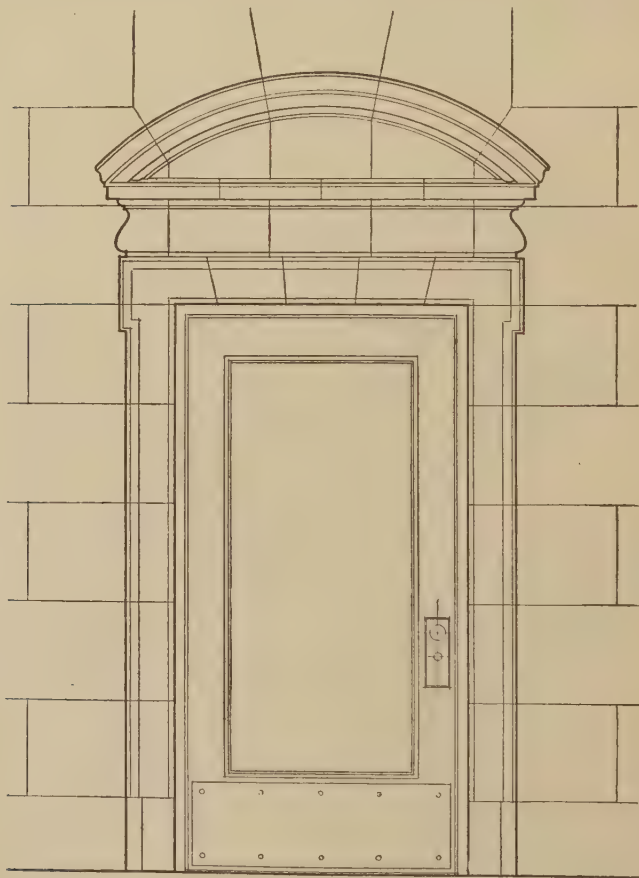


FIG. 22

ports that carry the masonry and terra cotta consist of three angles, as shown at *a*, *b*, and *c*, and one channel *d*. The angles *a* and *b* carry part of the brick wall, and the angle *c* and channel *d* carry the remaining part of the wall and the terra-cotta lintel. The steel member *d* supports the terra-cotta lintel

course *c*, which is suspended from the steel by means of rods *f* and anchored by the anchors *g* so that it is perfectly strong and rigid.

In this figure, sections are shown through the blocks which form the courses *c*, *h*, and *i* to illustrate how the blocks are formed to fit around the steel work and to show the rods and anchors that secure them in place. In (b) is shown a view of the steel supports *a*, *b*, *c*, and *d* that hold up the lintel. At *e* is shown one of the rods that carry the lower course of terra cotta. These rods are placed between the blocks of the lower course of the lintel, the upper ends of the rods are secured to the steel channel by means of clips *f*, and the lower end is bent around the short bar *g*, which extends through the end shells of two adjoining blocks. At *h* is shown a rod which is formed around the bar *g* and also over the horizontal flange of the angle *a*. This rod prevents the block from tilting when the succeeding course of terra cotta is put in place on top of it. At *i* and *j* are shown the galvanized iron bars that are used to anchor the terra-cotta blocks *h* and *i* in (a) to the steel lintels.

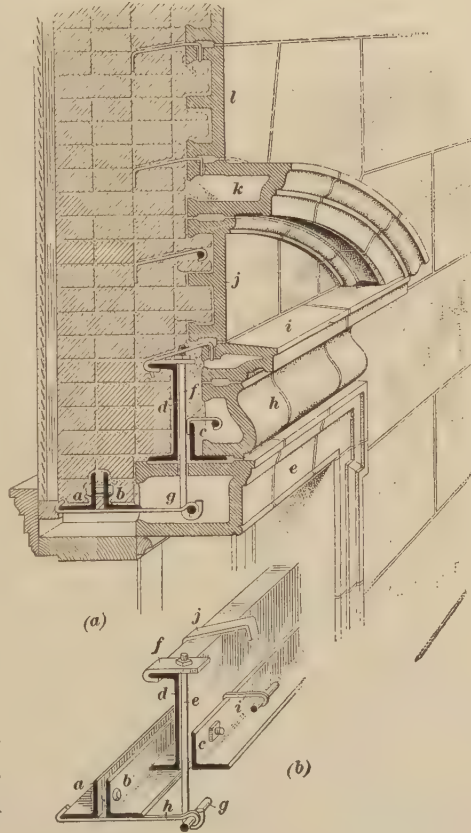


FIG. 23

The terra-cotta blocks *j*, *k*, and *l* in (*a*) are bonded with the brick wall and also anchored by bars as in the regular form of construction.

The terra-cotta lintels of the entrances shown in Figs. 2, 3, and 5 are all formed of courses of blocks and carried by steel members that are concealed in the masonry, thus permitting the exposed under side of the lintel, called the *soffit*, to be finished to correspond with the jambs, as is shown in Fig. 5. The principle involved in the construction of these lintels is the same as that shown in Fig. 23, the form of the blocks and the steel work being adapted to meet the requirements of the different designs.

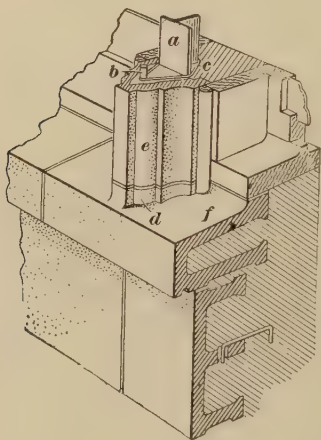


FIG. 21

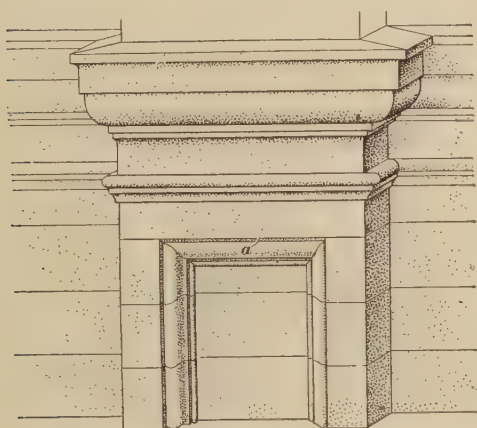
77. Window Mullions.

Window mullions or slender piers that are formed of terra cotta or have a facing of that material, should be provided with steel posts formed of **T**'s, angles, or gas pipe, to which the terra cotta may be anchored, and which will give stiffness to the piers.

In Fig. 24 is shown a mullion that has a terra-cotta facing. A steel **T** bar *a* is used to reinforce the mullion. A short iron bar *b* is placed in an opening in the top of the terra-cotta block and this is anchored to the **T** bar by means of a heavy wire. The bar *b* extends into the bottom shell of the succeeding block. Round or square bars of iron are sometimes used as anchors, one end being formed to turn down into the opening in the top of the block and the other end being formed to fit around the **T**. This method, however, does not anchor the bottom end of the succeeding block.

In this illustration it will be noted that the lower part *d* of the mullion is formed on the terra-cotta sill-course. This is done to secure a level bearing for the block *c*, as the sill is formed with a slope, as shown at *f*.

Examples of mullions which have steel reinforcement are



shown between the windows over the front entrance of the bank building illustrated in Fig. 3, between all windows of the residence shown in Fig. 7, and between the windows of the apartment building shown in Fig. 8. This reinforcement is absolutely necessary for the mullions shown in Fig. 7, as the mullion is too small to permit of sufficient masonry backing to give any strength to the terra cotta or to permit of anchoring the various mullions. The transom blocks which form the bars shown in this illustration are also reinforced with steel.

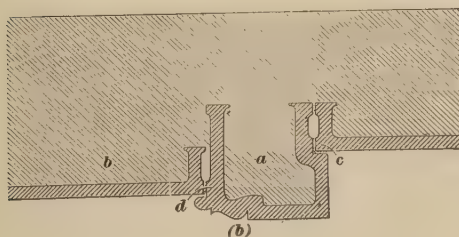
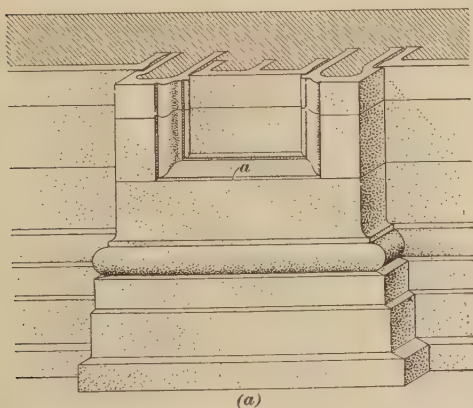


FIG. 25

78. Pilasters.

In designing pilasters, the forms of the blocks and manner of jointing them where they intersect with wall blocks require particular consideration in order that the

vertical joints may be concealed or, at least, not easily seen.

The pilaster shown in Fig. 25 has a paneled face and each course in the width of the pilaster is formed of three pieces. The panel is formed of one piece and the side members of the other pieces. At *a* in (*b*) is shown a plan of one side piece, and at *b* a portion of the panel. At *c* and *d* the manner in which the block is formed to conceal the vertical joints is shown. The moldings at the top and bottom of the panel, as

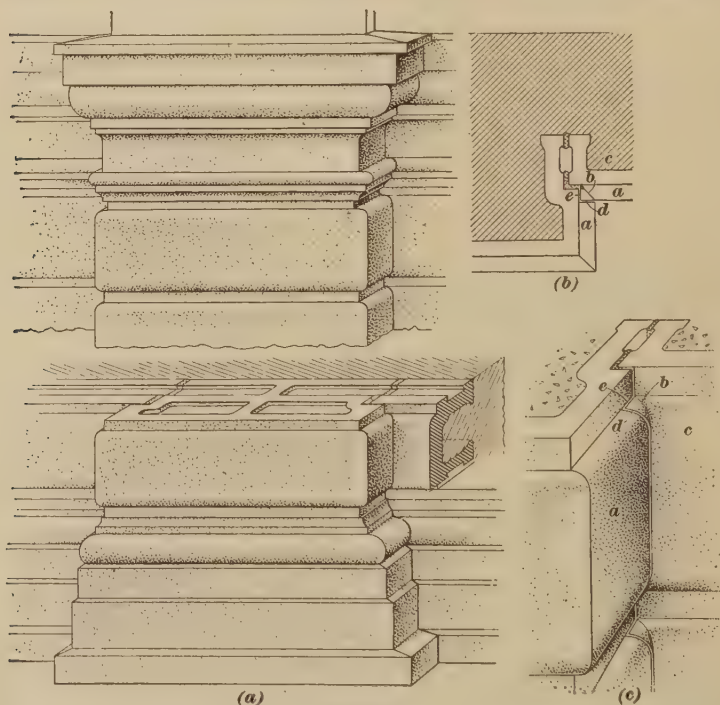


FIG. 26

shown at *a, a* in (*a*), are formed on the same blocks as the top and bottom sections of the panel.

The pilaster shown in Fig. 26 has horizontal joints known as *rusticated joints*. This is a very practical design for large blocks, as a slight warping of the blocks in the burning is less apparent than in the plain smooth-faced pilasters. In the rusticated design, the horizontal joints between the blocks are not conspicuous, as they are located at the tops of the recessed

surfaces between the projecting parts of the blocks. This design requires a somewhat different form of joint, however, at the intersection of the pilaster with the wall, as one part of the block projects beyond the other portions. In (b), at *a*, are shown these projecting parts, and at *b* is shown the return which is formed on the wall block *c*. In (c) is a view of this joint, showing the projecting part of the wall block *c* extending behind the similar portion of the pilaster block. The portions *d* and *e* of the joint will appear as shown. These joints should be made as thin as possible so that they will not be easily seen. This form of block allows of a square joint between the two intersecting blocks instead of a miter joint, and any cutting of the blocks that is necessary to make them fit properly may be easily done without disfiguring the joint.

79. Columns.—Columns of terra cotta are built up in sections from 10 to 16 inches in height, called *drums*, from their cylindrical drum-like shape. For columns not exceeding 14 inches in diameter these drums can be made in single pieces.

In the case of columns of large diameter, it is not practical to make the drums in one piece, as slight inequalities of shrinkage are likely to occur. The best practice is to use a sufficient number of vertical joints to make the drum of four or more pieces, depending upon the diameter of the column. The vertical joints should be continuous for the whole length of the shaft wherever practicable. The heights of the courses should not exceed 16 inches.

If the terra-cotta column is to enclose a structural-steel column, the drums must be made in pieces so that they can be placed around the steel column.

80. In Fig. 27 (a) is shown a terra-cotta column of small size, in which the drums can be made in one piece if desired. The drums are shown at *a, b, c*, etc. The drum *b* is in one piece, and *a* and *c* are each in five sections. A plan of the drum *b* is shown in (c) and a plan of the drums *a* and *c* in (b). The plan (b) shows the outer shell upon which the flutes are cast, also the radiating webs and the vertical joints between the sections. The right-hand side of the plan shows

the top of the block with anchors *d* holding the blocks together, also the raised parts of the bed joints *c*, which are ground

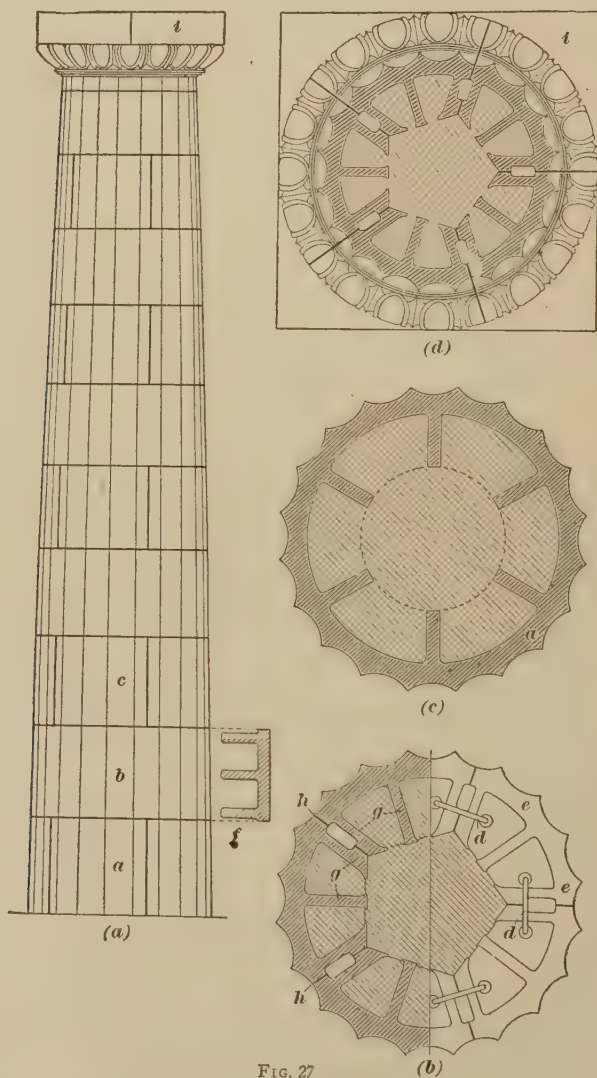


FIG. 27

when necessary to make the blocks fit together. At *f* in (a) is a vertical section through a block, showing the horizontal ribs

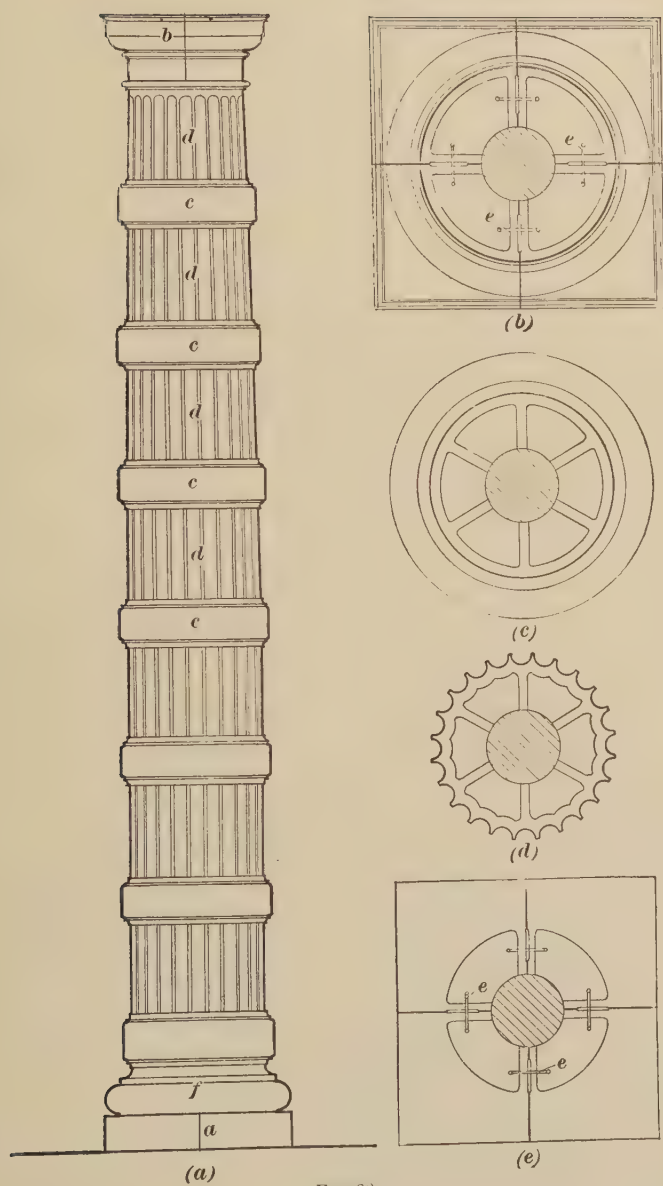


FIG. 23

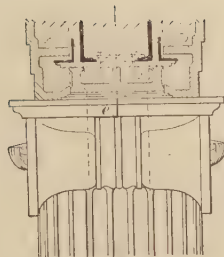
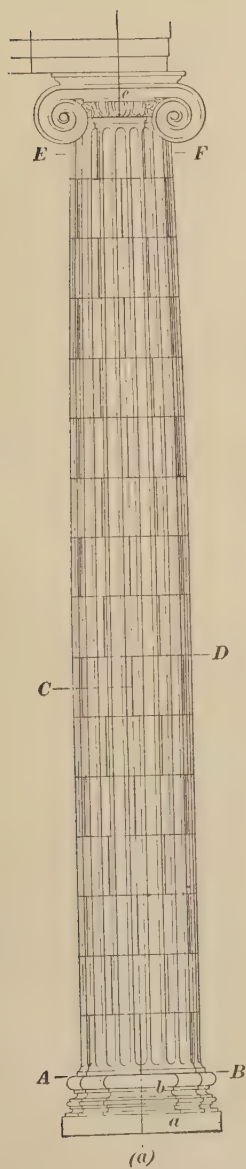
and the raised joints that are shown in plan at *e* in (*b*). The left-hand side of the plan (*b*) shows the radiating webs *g* and the joints *h*. The capital is generally made in sections. A plan of the capital of the column, in which the observer is looking upwards, is shown in (*d*). The ornamental portion of the capital is divided into five parts and the square abacus *i* into four parts.

81. When the column is built, the center of the column as well as the hollow spaces in the block are filled with masonry. Concrete is the cheapest and best material to use for this purpose. A column such as the one just described is not strong and should not be expected to support a great load. When there is a considerable load to be supported a steel column should be placed inside the terra cotta one in the manner that will be described later in connection with Fig. 29.

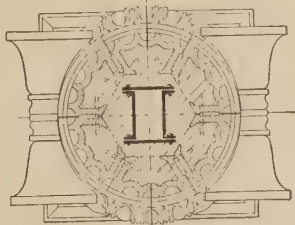
82. A design of column known as a *banded column* is shown in Fig. 28 (*a*). With the exception of the base *a f* and the capital *b*, the sections that form this column are all of the drum shape, made without vertical joints. The advantage of this design, for terra-cotta construction, is that the plain sections *c*, being located between the fluted sections *d*, conceal irregularities in the flutes that may be caused by the burning and which would be apparent were these fluted sections placed together. The forms of the shell and the interior webs of this column are similar to those of the column shown in Fig. 27.

A plan of the base block *a* in (*a*) is shown in (*c*). A plan of the cap viewed from the under side is shown in (*b*). Both base and cap are formed of four pieces which are clamped together as shown at *e* in both these figures. The clamps are shown in dotted lines, as they occur on the upper side of the capital and could not be seen in the view given. A plan of the circular portion *f* of the base is shown in (*c*), and the plan (*d*) represents the fluted drums *d* in (*a*).

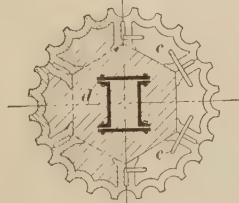
83. Columns that are required to support a weight in excess of the load the terra cotta will safely carry should be provided with a structural-steel column in the center. If the terra-cotta column is small and the sections are in single drums,



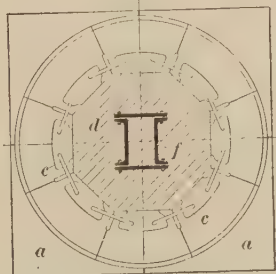
Side View of Capital
(e)



E-F Looking Up.
(d)



Section Through C-D
(c)



Plan of Base on Line of A-B.
(b)

FIG. 29

it will be necessary to erect the steel column first and lower the terra-cotta drums down from the top over the steel column.

Columns of large dimension cannot be economically or successfully formed in single drums, but must be built up of segments. Columns of this character usually contain structural-steel supports, and the terra-cotta segments must be designed to fit around the steel work which has been previously erected.

To conceal the vertical joints as much as possible in the completed column, frequently flutes and beads are employed in the design and the vertical joints are located in these members. Segments that form the columns should be anchored together by means of iron clamps hooked down into holes cast in the shell or webs of the units and the hollow spaces in the blocks should be filled with brickwork or concrete.

84. In Fig. 29 (*a*) is shown a fluted column having a molded base and an ornamental capital. This terra-cotta column encloses a steel structural column and is of a large diameter. The base, shaft, and cap are formed of several units and the joints between them are indicated in the illustration by heavy lines.

In (*a*) is shown the complete column. The base block *a* is formed of four parts, as in the square part of the base shown in Fig. 28. The molded base *b*, Fig. 29 (*a*), is shown in plan in (*b*) and is formed of eight segments which are bonded together by means of iron clamps *c*. A section through the fluted shaft of the column, taken on the line *CD* in (*a*), is shown in (*c*), six segments being used to form the drum. These are also anchored together by means of clamps *c*.

The right-hand part of this section is taken through the joint and therefore the clamps *c* can be seen. The left-hand side of the section is taken through the middle of the block and shows the concrete or cement filling at *d*. A plan of the under side of the cap, taken at *EF*, the observer looking up, is shown in (*d*); the heavy lines indicate the jointing of the four parts that form the cap. Joints on one side of the cap are shown at *e* in (*a*) and those of the other side of the cap are shown at *e* in (*c*).

The steel column around which the terra-cotta column is formed is shown at *f* in (*b*), and the space that is filled with concrete or brickwork is shown at *d*.

An example of cylindrical columns formed of plain blocks of terra cotta is shown in Fig. 3. In Fig. 2 are shown columns that have structural-steel members in the cores. These columns are designed so that the vertical joints between the blocks occur

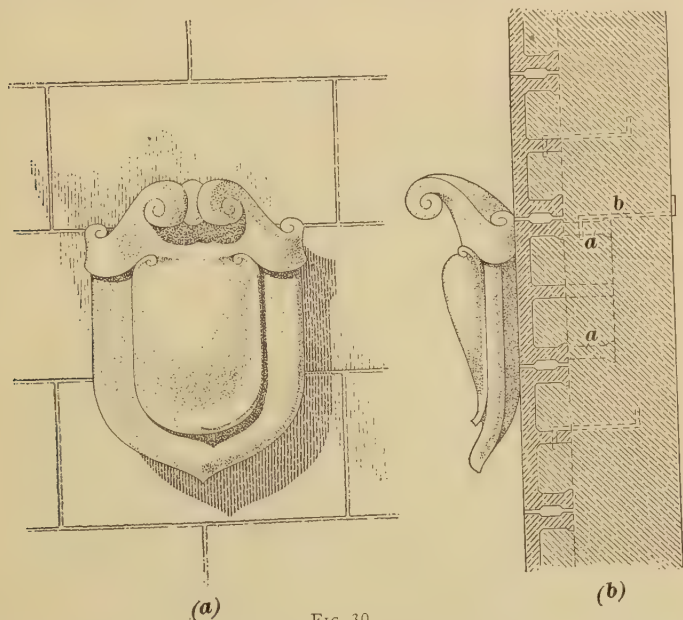


FIG. 30

at the angles of the columns and are thus partly concealed by an ornamental beaded treatment.

85. Cartouches.—A cartouche is a form of ornament consisting generally of a panel in the shape of a shield, oval, or rectangle, which is surrounded by ornaments consisting of ribbons, scrolls, foliage, etc. The central panel may be decorated with a coat of arms, a motto or some similar motif, or left plain. Cartouches are used frequently as a means of decoration and their ornamental character makes them expensive to execute in stone. They are, however, comparatively inexpensive

sive when made of terra cotta. A small cartouche is shown in Fig. 30. An elevation is shown in (*a*) and a side view in (*b*). The method of securing the cartouche to the wall is shown in (*b*), in which the block, of which the cartouche is a part, extends back into the wall as shown at *a*, and an anchor *b* firmly secures the cartouche to the wall.

86. Cartouches are often quite large and made up of several blocks. The joints in such cases are carefully designed so



FIG. 31

as not to cross the principal parts of the cartouche. An example of a large cartouche is shown in Fig. 31. Joints are shown on each side of the helmet and in corresponding positions in the lower part of the cartouche. The shield containing the eagle is in one piece, as a joint through this part of the cartouche would be unsightly.

87. A very conspicuous example of the use of terra-cotta cartouches in the design of the building is shown in Fig. 8. In this design cartouches form the central parts of ornamented panels, as in the panel immediately over the entrance to the building; in other places they are used as inserts in the wall.

88. Balustrades.—Vertical members of terra cotta, such as balusters, urns, finials, etc., are usually formed of small pieces and held together by round iron rods extending up

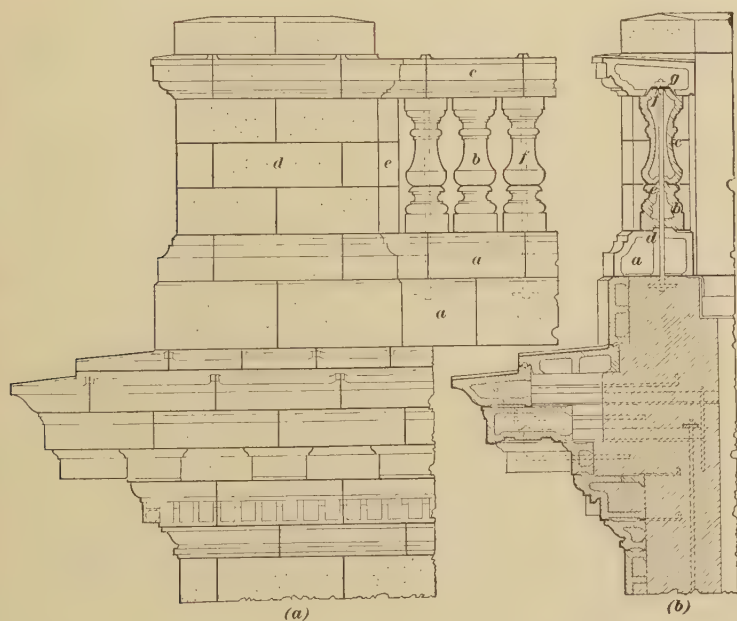


FIG. 32

through hollow cores in the centers. On each end of these rods is a nut and washer, and when the top nuts are tightened the different pieces of terra cotta that compose the baluster or finial are drawn closely together.

When balusters are short, each can be cast in a single piece having a hollow core to receive the rod and to permit of proper shrinkage in the burning. Long balusters can be molded in halves, which, after drying, are placed together and the joints smoothed off and finished so they will not show. The com-

pleted baluster is then placed in the kiln and burned. When a long baluster consists of a base, shaft, and cap, however, joints are formed in the baluster so that it may be cast in three pieces, each of which is small. The twisting and warping due to burning is thus reduced to a minimum.

Balustrades are formed of a series of balusters which rest on a terra-cotta base and are covered at the top by a terra-cotta cap, or railing, and the balusters are anchored to this base and cap to make a strong and rigid construction.

89. A portion of a balustrade of this description is shown in Fig. 32 (*a*) and a section through the balustrade and one of the balusters is shown in (*b*). In (*a*) an elevation of the base on which the baluster rests is shown at *a*, the baluster at *b*, and the cap, or railing, at *c*. The balustrade terminates at the end of the building in a pier as shown at *d*. This pier is faced with regular-shaped terra-cotta blocks and is constructed in the same manner as terra-cotta faced walls. At *e* is a plain pilaster adjoining the pier.

The dotted lines at *f* indicate a rod that extends from the base, through the baluster, and into the cap. In this illustration the rods are inserted in every other baluster instead of in each one. In (*b*) is shown a section through the balustrade in which the baluster is shown to be formed of two parts, *b* and *c*. Dowels are formed on the base *a* and also on the members of the baluster which fit into corresponding recessed parts as are shown at *d*, *e*, and *f*. At *g* is shown a flat bar that extends the entire length of the balustrade and through which the rods pass and are secured. This portion of the balustrade requires to be completed before the cap members are set in place.

90. Domes.—Architectural terra cotta has come into wide use as a facing material for the interior and exterior surfaces of domes. It is particularly adapted to this use because the material is light in weight and permits of extensive color effects, and is impervious to the weather.

The terra-cotta facing is supported on a frame made of rolled-steel sections of light weight, or, more generally, on a light concrete dome which may or may not be supported on

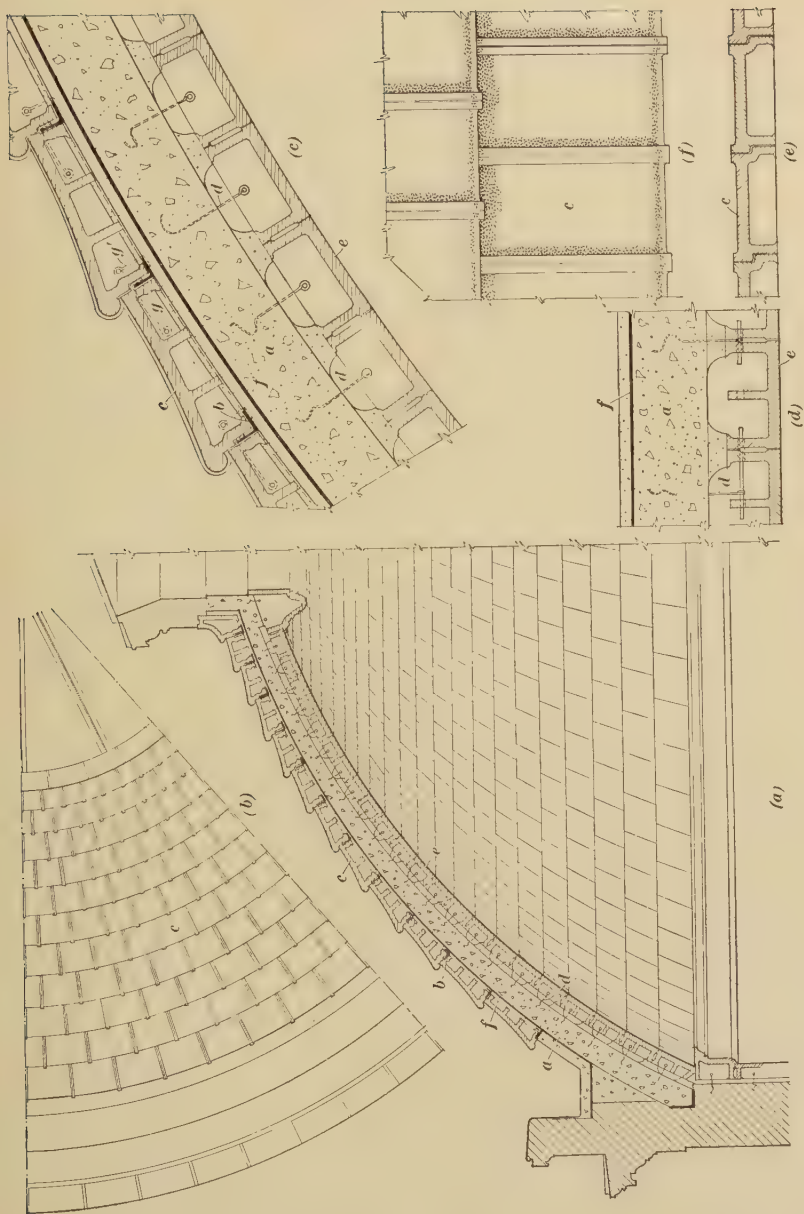


FIG. 33

steel shapes. Fig. 33 shows the construction of a dome made of concrete which is faced both on the outside and on the inside with terra-cotta blocks. In (*a*) is a cross-section through one half of the dome and in (*b*) is a plan of part of the outside terra cotta. The reinforced concrete which forms the structural base on which the terra cotta rests is shown at *a* in (*a*). The steel angles to which the outside terra-cotta work is attached are shown at *b*; the exterior terra-cotta blocks *c* rest on the angles as well as on the concrete and are also wired to the angles.

The blocks used on the outside of the dome have lips that project over the next row of blocks below. The vertical joints between these blocks are rectangular raised joints, as shown in (*e*) and (*f*). A dome constructed in this manner should have a waterproof coating of felt and tar above the concrete and under the terra cotta to prevent water from working its way through the dome from any leaks that may occur in the raised joints of the outside terra-cotta covering. This waterproofing is indicated at *f* in views (*a*), (*c*), and (*d*). All the outside joints should be filled with roofer's elastic cement to insure their permanence and waterproofing value.

A section through the individual blocks is shown at *c* in (*c*). The steel angles *b* support the blocks which rest against them, and, in addition, the blocks are wired to the angles as shown at *g, g'*. These wires extend between the joints of the blocks and are secured to pins that pass into holes in the adjacent blocks. A section through the raised joints is shown in (*e*). The wire just referred to is placed in the joints between the blocks. The joint is rabbetted, which tends to make it waterproof, but should nevertheless be filled with good elastic cement. The tiles themselves are also set in elastic cement.

The inside lining of the dome, as shown in Fig. 33 (*a*), is formed of blocks *e* secured to the concrete dome by means of stout wires *d* that are set in the concrete when it is cast. These wires, shown more clearly in (*c*) and (*d*), extend below the lower surface of the concrete and their lower ends are fastened to short rods that extend through holes that occur in all the blocks and thus the blocks are held securely in place.

SHIPPING AND HANDLING TERRA COTTA

91. Packing.—Terra cotta is usually shipped from the factory in box cars, as they afford better protection for the blocks than open cars do.

The blocks should be carefully packed with plenty of hay or straw surrounding them. They should be laid in courses in the car and be so placed that no finished edges or faces come in contact with the car or adjoining pieces. All blocks should be so braced or wedged with the straw or hay that they cannot move about in the car.

The courses, or layers, in the car should consist of blocks having consecutive numbers, so that when the blocks are removed from the car upon its arrival at its destination they may be stacked in corresponding layers, or courses. This method will facilitate finding the blocks in their proper order when they are to be placed in the wall.

92. Receiving and Checking.—When shipping the terra cotta, the manufacturer always sends to the contractor who is to erect the material a list of the pieces included in the shipment.

When the blocks are received at the building they should be checked with the list, and if any listed pieces are missing, the factory should be notified immediately so that the pieces needed may be shipped without delay.

93. Assorting and Stacking the Blocks.—As there is danger of the terra cotta being chipped by frequent and careless handling, it should be assorted as it is received at the building and stacked in such a manner that it will not need further handling until it is required to be placed in the walls of the building. For this reason it is customary to form separate stacks of the blocks that form each part of the design, and to place the blocks that are required first at the top of the stack.

In stacking the blocks, care should be taken to prevent all edges and finished faces from coming in contact with hard substances or with one another. The best method is to pile the pieces in layers with strips of boards between the layers.

If blocks are not to be used immediately, they should be stored in a shed or be covered with boards and waterproof paper to prevent their being injured. If a block is broken it will take from six to eight weeks to send to the factory and duplicate it.

94. Handling the Blocks.—In conveying the blocks from the stacks to the scaffold, the pieces should be carried singly, if possible, one block of ordinary size being a good load for one man. If it is necessary to use a wheelbarrow, the block should be placed on straw with the face up and only one block should be carried at a time, unless the blocks are very small. In that case several small blocks may be placed in the wheelbarrow, provided that straw is carefully packed around them.

SETTING THE TERRA COTTA

95. Backing-Up the Blocks.—Terra cotta is backed up with masonry in much the same manner as cut stone or face-brick work. When terra cotta is used as a veneer for a masonry wall, the hollow spaces in the blocks are generally filled with masonry. When the terra cotta projects beyond the face of the wall, the masonry filling of the blocks usually does not extend very much beyond the face of the wall, consequently steel anchors, such as have already been described, are used to tie the terra cotta to the masonry. These anchors if not embedded in masonry should in all cases be covered with cement grout as a protection against rust. It is dangerous to omit this protection.

Terra-cotta facings for concrete walls frequently do not permit of filling the back of the blocks with masonry, but grout may be poured back of the blocks to fill the voids, if the circumstances require it.

96. Fitting.—While terra-cotta blocks are usually fitted together and the edges jointed at the factory, occasions arise when it is necessary to cut the blocks at the building before they can be set in place. This may be due to errors in measurements or to irregularities in the structural parts of the building.

The shells and webs of the blocks sometimes require to be cut to fit structural-steel members or to provide additional openings into which anchors may be placed. This cutting should be done only by skilled workmen and every precaution should be taken not to injure the block either on the exposed face or in the parts that are essential to its strength and anchorage. It is, however, not often necessary to fit the terra cotta at the building.

97. Anchoring.—The method of anchoring terra-cotta blocks will depend upon the form of the blocks and the structure to which they are to be attached and must be adapted to meet the peculiar requirements of each case.

The most essential feature of the anchor, next to its strength, is that it shall form a rigid connection between the block and the backing to which it is fastened. The manner in which it is made rigid will depend upon whether the anchor is of a form that can be adjusted or one that is of a fixed form.

Horizontal anchors that connect with the blocks and extend back into the masonry do not require to be adjustable. They are set into the holes of the blocks and masonry is built around the opposite ends so that when the mortar becomes hard the anchors cannot be moved.

Anchors that fit over a structural-steel member back of the block are sometimes formed by bending one end to fit into the block. The anchor is then placed in position and by means of a hammer, the opposite end is bent so that it will accurately fit over the steel. This method is possible only where the anchors are formed of small bars or straps that can be bent without endangering the terra-cotta blocks.

When heavy anchors are used to fit over structural-steel members, they may be formed with turned-down ends and of such lengths that they can be easily driven into position. They may be made slightly longer than required, and when set in place may be wedged at either end by means of small pieces of broken terra-cotta blocks until they are rigid, after which mortar should be slushed around the anchor connection at the block to make sure that the anchor will remain in place.

For overhanging blocks that are carried by suspension rods, an adjustable form of hanger is used. The lower end of the rod is formed with a hook through which a bar extends horizontally into adjacent blocks. The upper end of the suspension rod is provided with a screw thread and nut. The horizontal bars afford a bearing for the terra cotta and the suspension rods are brought to a rigid condition by screwing down the nuts on the upper ends. In this manner the entire weight of the block is carried by the rod.

98. Bedding in Mortar.—All terra-cotta blocks should be well bedded in mortar and pressed down so that each piece will have a uniform bearing throughout the length of the block. Mortar joints for the top surfaces of all sills, projecting courses, cornices, and copings should be carefully formed so that no openings will be left through which water may enter the joints.

In setting heavy pieces of terra cotta, wooden wedges of uniform thickness are sometimes placed in the mortar bed to secure joints of uniform sizes, as the weight of the block would otherwise cause the mortar to be pushed out of the joint before the mortar becomes hard.

The mortar joints at the face of the wall frequently are finished as the blocks are laid, instead of being pointed later. When this is to be done, a rough mortar joint is formed with the trowel when the block is put in place and in the course of several hours, when the mortar has become sufficiently hard, it is smoothed with a tool to secure the form of joint desired.

99. Filling.—For large projecting cornices, such as shown in Fig. 21, concrete is sometimes used as a filler, as shown at *o*, instead of terra cotta.

On this filler is placed a row of regular building tiles *p* to form a surface on which the sheet-metal covering *q* may be laid. This covering extends over the front member of the cornice and returns into a groove, or reglet, that has been formed in the face of the blocks, as shown at *r*. It is secured in place by means of wedges of lead and the intermediate spaces are filled with roofer's elastic cement. At the wall, the

sheet metal turns up as shown at *s*, and is cap-flashed in the usual manner, as shown at *t*.

100. Mortar.—Mortar for setting of terra cotta is usually formed of cement and sand, with a small amount of thoroughly slaked lime added to make the mortar more plastic and thus facilitate its spreading. Mortar for this purpose should be composed of one part Portland cement and two parts of clean sand and $\frac{1}{10}$ part of hydrated lime.

Lime mortar is not suitable for this form of construction, as it sets slowly and therefore prevents rapid progress with the work, for the weight of the terra cotta would squeeze the mortar out of the joints before it had time to become hard. Lime mortar will, moreover, disintegrate in time and leave open joints.

When the joints in the terra cotta are to be pointed after the work has been completed, the mortar in the joints should be raked out to a depth of from $\frac{1}{2}$ inch to 1 inch as soon as the blocks have been set. Also, loose particles of mortar on the face of the blocks should be removed to facilitate cleaning the blocks later on.

101. Protecting the Terra Cotta.—All projecting members of terra-cotta courses should be temporarily protected after the blocks are laid, so that they will not be broken by falling bricks or other building material. Planks or boards are used for this purpose and it is usually specified in the carpenter's, mason's, or the terra-cotta contract, that the contractor shall protect all terra-cotta work until completion of the building. A board slightly wider than the projection should be laid along all projecting members and fastened securely in place by crosspieces tacked to window frames, floor joists, or wherever it is possible to make a fastening. Ornamental panels or other ornamental terra-cotta work should be entirely covered to make sure that they will not be injured during the process of building.

102. Terra-Cotta Foreman.—For a large or complicated job of terra cotta, a terra-cotta foreman, who is an expert

in this work, is sometimes employed, at the owner's expense, to supervise the terra-cotta work.

It is the duty of this foreman to see that the material arrives on the building site at the proper time and in sufficient quantities so that there will be no delay in erecting the building. He also checks off the blocks to see that they are all at hand and causes them to be piled in such order that they can be taken as wanted without unnecessary delay or lost labor.

He is responsible for the proper stacking of the blocks to keep them from injury and for seeing that they are covered up and protected with planks or boards. The supervision of the actual setting of the blocks is also part of the duties of the terra-cotta foreman.

103. Washing and Pointing the Terra Cotta.—As a general rule, terra-cotta blocks are laid up without the joints being pointed, the rough mortar of the joint being raked out slightly before it becomes hard. Just before the completion of the building, the face of the terra-cotta work is washed and the joints pointed. This work can be done by the masons who set the terra cotta or by another contractor who is a specialist in this line of work. The latter is the usual practice for cleaning buildings composed of brick or stone walls and terra-cotta trimmings, and one contractor is then responsible for the cleaning and pointing of the face of the entire building.

Unglazed terra cotta should be washed with a weak solution of muriatic acid such as is used in cleaning brickwork, a 3-per-cent. solution being sufficiently strong for this work. This may be applied with a coarse brush and the surface of the terra cotta scrubbed until all cement stains and lumps have been removed. Steel brushes, such as are used in cleaning stone and brickwork are not suited for cleaning terra cotta, however, as the steel bristles may injure the glaze of the material. Steel or iron tools, pails, etc., should never be used in connection with acid in cleaning the fronts of buildings. Glazed terra cotta never requires acid. The best cleaning material to use is an abrasive soap or washing powder. Lumps of mortar should be soaked with water and removed with a wooden stick.



Courtesy of the Atlantic Terra Cotta Company

FIG. 34



FIG. 35



FIG. 36

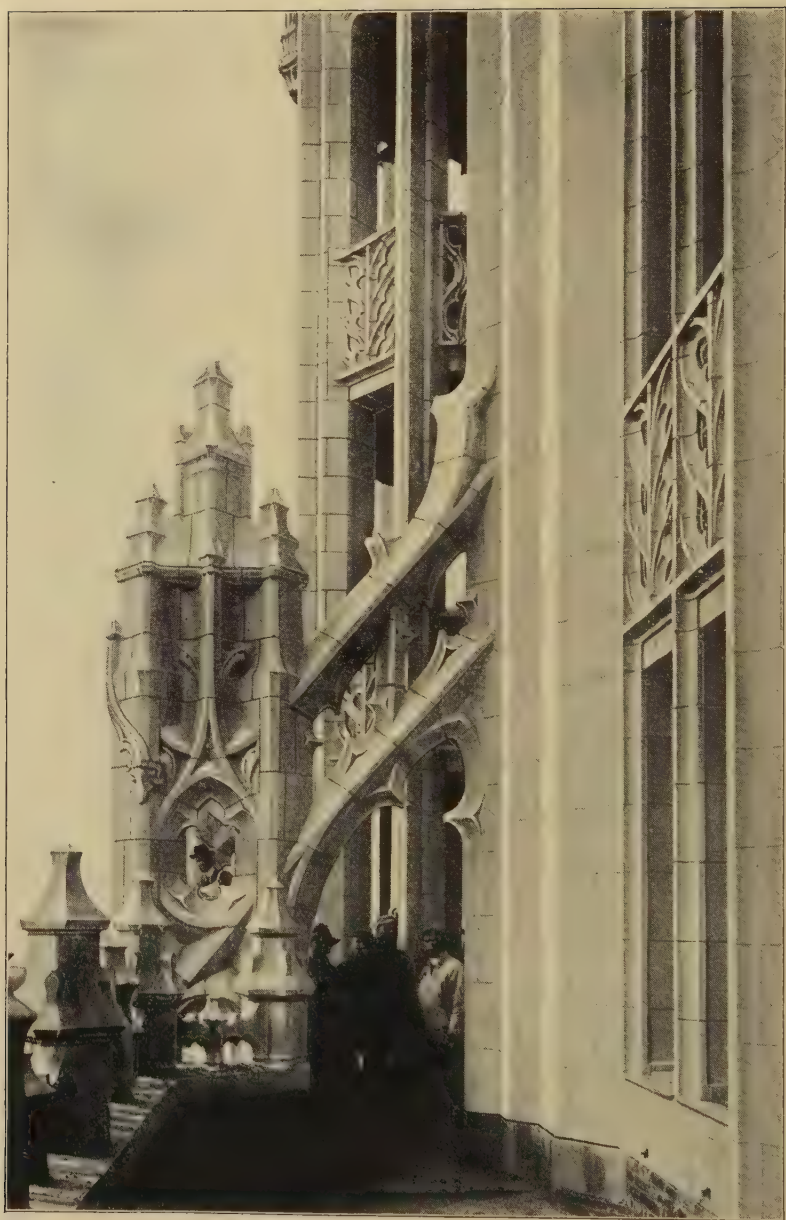


FIG. 37



FIG. 38

The pointing materials may be ordinary cement-and-sand mortar, white-cement mortar, or colored cement mortar, as may be desired. For white enameled terra cotta, white mortar is generally used to make the joints as near the color of the terra cotta as possible. Pointing mortar may be colored any desired shade to match any color of terra cotta, but mineral colors only should be used, as coloring matter composed of vegetable colors will fade.

Joints in terra cotta are usually close, and the pointing is done with a tool about an eighth of an inch in thickness. This tool makes a joint that is slightly depressed at the center and the mortar is pushed firmly against the edges of the blocks.

EXAMPLES OF TERRA-COTTA WORK

104. One of the most noteworthy examples of terra cotta applied to the exterior of a building is shown in Fig. 34, which is a view of the Woolworth building in New York City. The general color of this building is a light cream, while the panels between the windows are finished in various colors such as golden yellow, green, sienna, and blue. The style of architecture employed is Gothic. The terra cotta, which is mat-glaze finish, was set in mortar composed of cement, white sand, and a waterproofing compound. The building was washed down with Gold Dust washing powder and sand grit, no acid being used in cleaning.

105. Notwithstanding the lightness and delicacy that characterize the appearance of this building, the details when seen at close range are very large in actual size, as shown in Fig. 35. In this illustration is shown the figure of a man which gives an idea of the relative size of the ornament. Other examples of the details used in this building are shown in Figs. 36 and 37. In Fig. 38 is shown a detail of two windows in one of the upper stories of the building. At the sills of the lower windows is shown the method of protecting portions of the ornamental work by means of boarding.

HOLLOW TILE

ADVANTAGES AND NATURE OF HOLLOW TILE

1. Introduction.—Hollow terra-cotta blocks have been used for many years as a means of protecting the steel constructional parts of tall buildings from fire, as well as for constructing fireproof partitions, furring, etc. The employment of hollow terra-cotta blocks for the outside walls of buildings, particularly of residences, is more recent. Their use for this purpose is, however, quite extensive, and hollow-tile construction for walls of buildings has become thoroughly standardized. This style of construction is being used with increasing frequency where low-priced fireproof buildings are in demand.

2. Advantages of Hollow-Tile Construction. There are several advantages claimed for hollow-tile construction. Compared with wooden construction, it has the advantages that any masonry construction has over wooden construction; namely, greater stability, durability, and fire-resisting qualities, as well as a lower cost of maintenance. No matter how carefully a frame building is built and regardless of the excellence of the materials used and the high quality of the labor employed, its life is comparatively short. It must be kept in repair, and there is an increasing necessity for repairing as time goes on. Hollow-tile buildings, of course, also will need repairs, but the repairs necessary to keep a tile building in good condition are very much less than for a frame building. Hence, although the first cost of a building of hollow-tile con-

struction is greater than one of wooden construction, the ultimate cost, including cost of maintenance, when extended over a period of years, is less for the tile construction.

3. In the United States, where wood has been very plentiful and comparatively cheap, frame construction has flourished, but the enormous loss by fire in frame buildings is gradually leading to the erection of fireproof buildings of masonry.

Since tile is made of clay and has been thoroughly burned, it has fire-resisting qualities similar to those of brick, and buildings made of it can obtain low insurance rates.

For garages, hollow tile is one of the best materials that can be used, since it is not only economical and durable but possesses the most important requisite of any well-designed garage, that it shall be fireproof. It is not necessary to plaster the tile on the inside of a garage, as the wall can be made attractive by selecting tile with one face smooth or glazed and carefully pointing up the joints.

4. Another claim that is made for hollow tile is that it is sanitary and vermin proof, which makes it particularly adaptable for use in residences.

5. A further advantage of hollow-tile construction is that it is generally less expensive than any other form of masonry construction. This is an important consideration in the minds of architects and their clients. This economy in first cost is brought about partly by the nature of the hollow tile. Each tile is much larger than a brick and can be laid much more quickly than an equal volume of brickwork. A workman can, consequently, lay more cubic feet of wall with tile than he can with brick in a working day. The tiles are easily manipulated and can be broken and trimmed to fit peculiar conditions that are found when building walls.

Hollow-tile walls are strong and light in weight, which makes the load on the footings less than that of a solid brick wall. This saving in weight means an economy in the size and cost of the footings.

6. Another advantage claimed for hollow-tile construction is that the walls and floors are hollow. Each block of hollow tile consists of a sort of clay box divided by interior webs or partitions so that a wall built of hollow tile is honeycombed with holes. These holes, or cells, are excellent in many ways. For instance, the dead air contained within these cells provides excellent insulation against temperature changes, so that a hollow-tile wall is usually warmer in winter and cooler in summer than a wall of solid masonry. These cells also prevent the penetration of water through the walls.

7. It is claimed that interior plastering can be safely applied directly to the hollow-tile blocks, thus saving the cost of furring and lathing. It is not considered good practice to plaster directly upon the inner surface of a solid brick or stone wall, as dampness often works its way through and is apt to stain the surface of the plaster and to destroy decorations or papers that may be applied to the plaster.

8. Walls of hollow tile are easily arranged to contain heating and plumbing pipes as well as electric wires and conduits, either by building chases in the wall in advance of the installation of the pipes or by placing the pipes first and building the blocks around them. A common method, when the cells are set vertically, is to break slots or chases in the completed wall when it is time to run the pipes. This is easily accomplished, as the webs are quite thin and can be broken by sharp blows of a hammer and chisel. Care must be exercised, of course, in breaking into the finished wall to avoid damaging it too much.

9. **Manufacture of Terra-Cotta Tile.**—The manufacture of terra-cotta hollow tile is a comparatively simple process and consists, briefly, of kneading clay until it is of the proper consistency for molding, after which it is shaped into blocks and then baked in kilns.

10. **Density of Terra-Cotta Tile.**—Hollow terra-cotta tile is made in various densities, and three classes of the material are commonly recognized; namely, *dense*, *semiporous*,

and *porous*. These terms, however, are somewhat indefinite. For instance, when a kiln of tile is burned, the material closest to the fire is burned the hardest and consequently is dense, while the remainder of the tile in the same kiln might be classified as semiporous. Porous tile is of a different composition, and when burned is filled with numerous air spaces which make this material light and porous.

Most of the tile now manufactured is of the semiporous class because semiporous tile has been found by experience to be the most satisfactory ware.

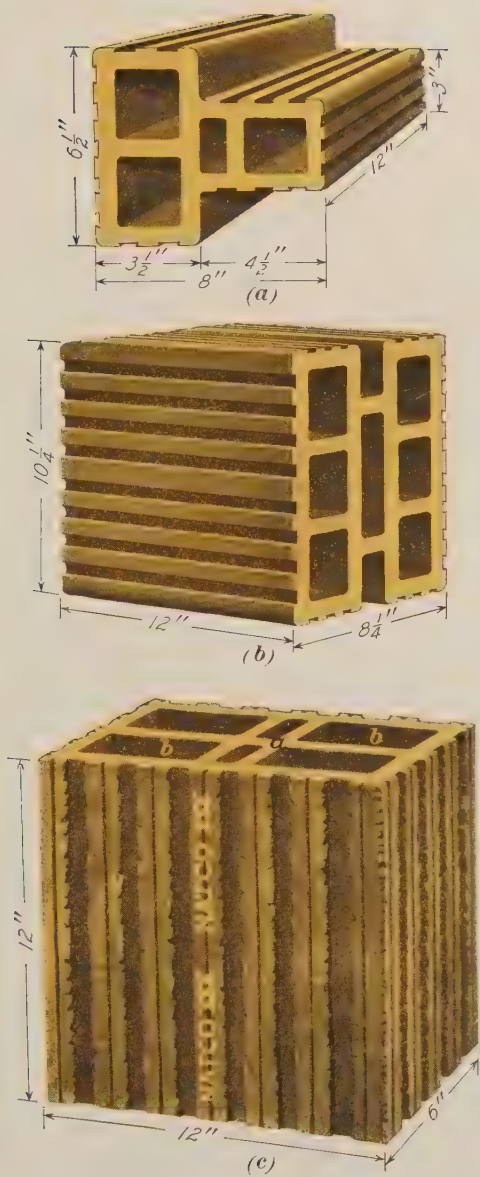
A frequent requirement of building codes regarding the density of tile is as follows: "Tile used for bearing walls shall not have more than 12 per cent. absorption." That is, the tile when immersed in water shall not absorb more than 12 per cent. of its weight of water.

11. Dense Tile.—Dense tile, being burned the most, is therefore hardest and strongest, and is used where heavy loads are to be supported. It is used where walls are to be veneered with brick or where the tile is exposed to the weather. Unless the surface is scored, or grooved, plastering will not adhere to the surface of dense tile.

12. Semiporous Tile.—Semiporous tile is the kind most used in houses and small buildings. Tile of this class is sufficiently hard burned to be fairly impervious to moisture and to make good substantial walls, but not too dense to prevent plaster adhering to it strongly. The tiles are, nevertheless, generally scored or grooved so as to afford a good bond for plaster or mortar.

13. Porous Tile.—Porous tile is rarely used and should never be employed for any purpose except for building inside walls, or partitions.

14. Glazed Tile.—Tile for certain purposes is sometimes glazed. Glazing is done by introducing a quantity of common salt into the kiln when the material is nearly burned and this produces a glass-like film over the entire exposed surface of



the tile. This tile must be grooved if it is to be plastered, as plaster or mortar will not adhere strongly to a glazed surface.

15. Vitrified terra cotta is generally made of fireclay or shale and is burned at a high temperature so that the material begins to fuse and is extremely hard throughout. This form of terra cotta is the densest kind, and is used for silos and other buildings in which the surface of the tile is exposed directly to the weather.

SHAPES AND KINDS OF HOLLOW TILE

16. Forms of Hollow Tile.—Hollow tiles used for the erection of the walls of buildings are made in three different general forms. These forms are shown in Fig. 1. In (a) is a **T-shaped** tile, known as an *interlocking tile*; in (b) an **H-shaped** tile, known as a *load-bearing tile*; and in (c) a regular, or box-shaped, tile. All these forms consist of units of burnt clay having outer shells and thin partitions, or *webs*, which divide the blocks into *cells*. These webs are shown at *a*, and the cells at *b* in (c). The shells are about $\frac{3}{4}$ inch and the webs about $\frac{5}{8}$ inch in thickness.

REGULAR, OR BOX-SHAPED, TILE

17. Description of Regular Tile.—In Fig. 2 are shown illustrations of some of the forms in which regular tiles are made. The blocks shown at (a) and (b) are used for closers and face blocks, as will be shown later on. Those at (c) and (d) are for building straight walls of different thicknesses. The blocks shown at (e), (f), (g), and (h) are modified forms of these regular blocks and are manufactured by the National Fire Proofing Company. They are known by the name of *Natco* hollow tile. Fig. 1 (c) is an illustration of a standard Natco block, showing in detail the arrangement of webs and the dovetailed scorings which are designed to afford a good grip for mortar and stucco.

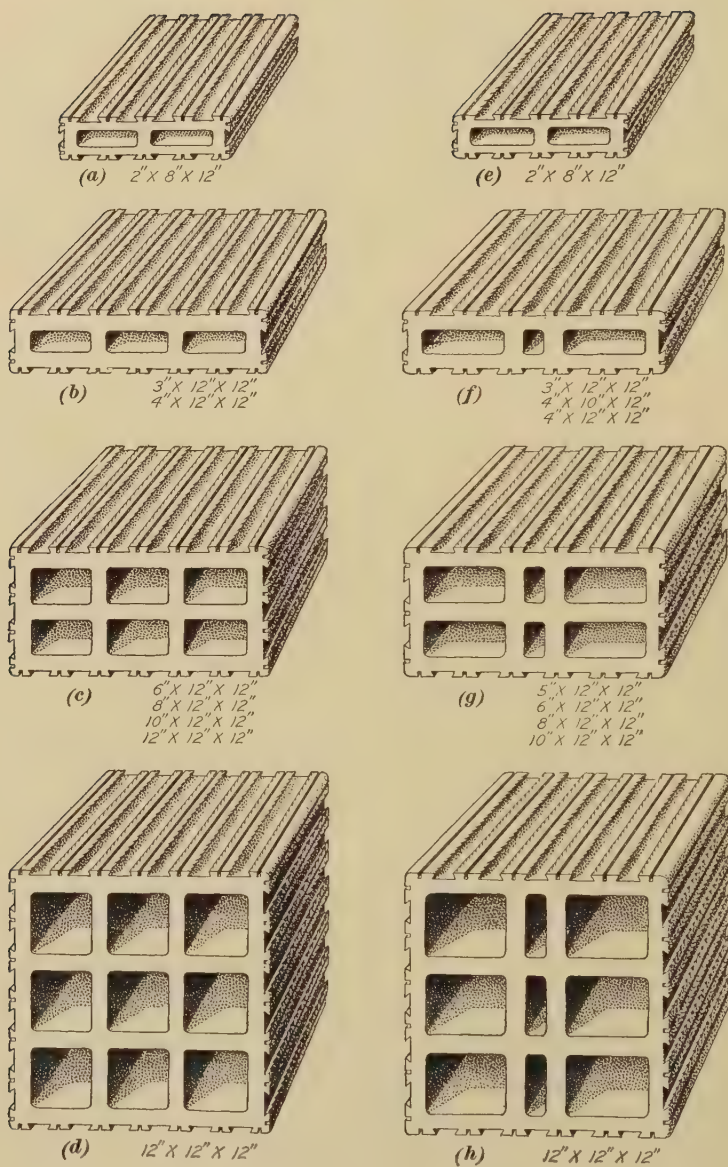


FIG. 2

By special arrangement of the webs and cells which is shown in Fig. 1 (c) and in Fig. 2 (g) and (h), the webs of the block above always rest directly upon the webs of the block beneath

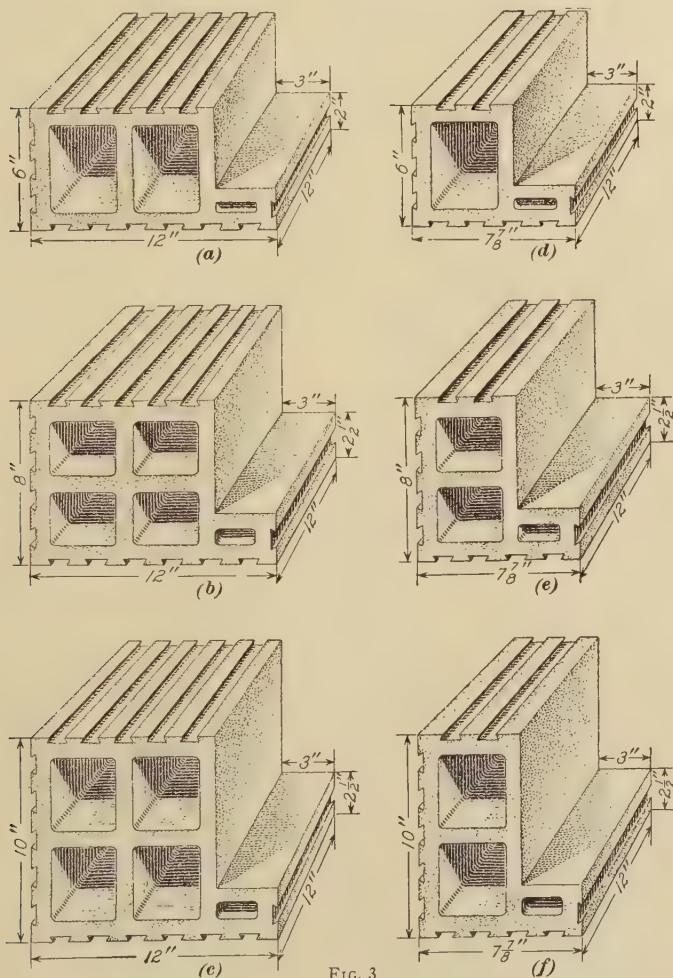


FIG. 3

when the joints are broken. The load on the tile is thus carried down to the ground by continuous webs of solid terra cotta. This also brings the cells into a continuous line from the top to the bottom of the wall so that they are available as pipe chases.

In Figs. 3 and 4 are shown jamb blocks and half jamb blocks, which are used for the jambs or sides of window open-

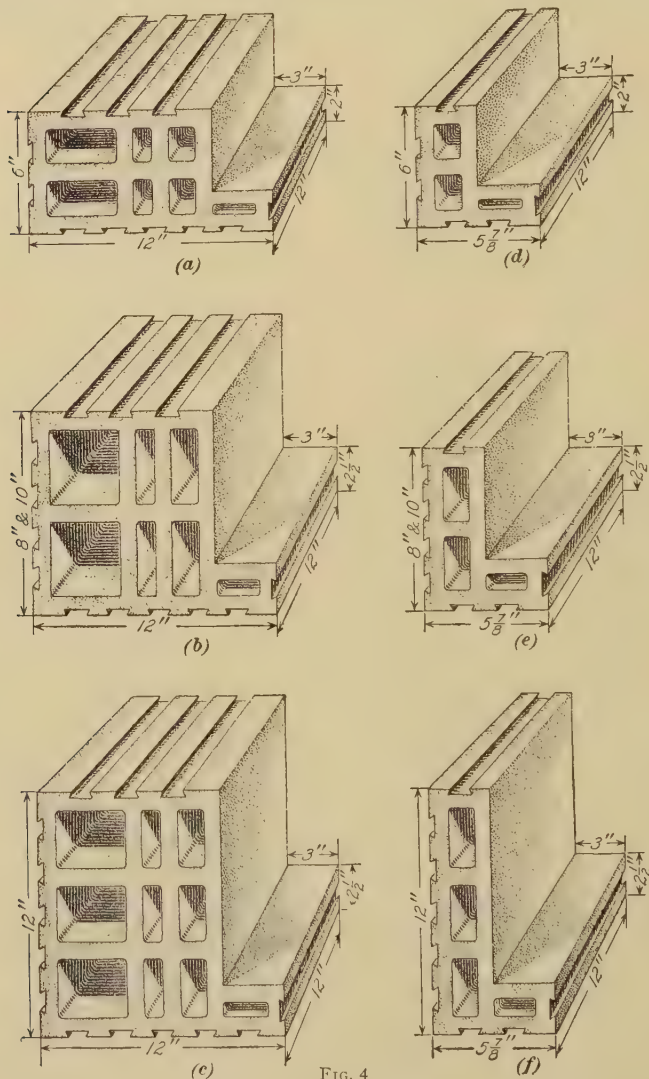


FIG. 4

ings when box window frames are used. In Fig. 3 are those that are used in connection with the regular blocks, and in Fig. 4

are similar blocks that are used in connection with the Natco blocks.

18. In Fig. 5 are shown box-shaped hollow tiles, made by the National Fire Proofing Company, which possess features that differ from those of the blocks already mentioned. For instance, these blocks are 5 inches in height instead of 12 inches and have double shells on the outer and inner faces

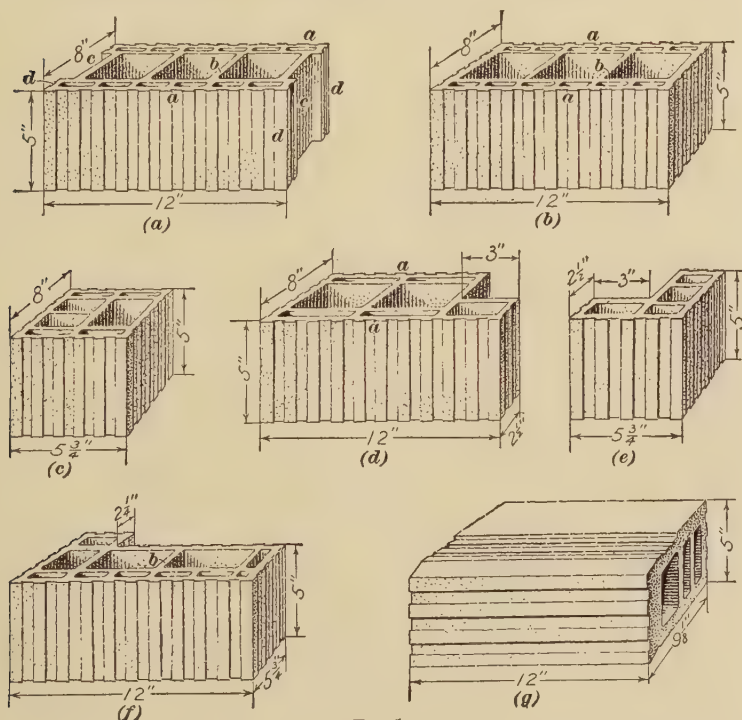


FIG. 5

of the principal blocks as shown at *a* in the different views in the figure. The cross webs *b* serve to tie the two faces *a*, *a* together, as shown in (a), rather than to support loads. Another feature that is different is the formation of the ends of the wall blocks (a). They are made with a hollow space *c* at each end so that the mortar joint does not extend through the wall but is placed on the surfaces *d* only. When the blocks

are set in place together this hollow space breaks the continuity of the mortar joint.

In Fig. 5 (a) is shown a standard wall block, in (b) and (c) *closure* tiles, or *closers*, for closing the ends of the cells in the tile at the end of a wall or at a door jamb. Jamb tiles and half jamb tiles are illustrated in (d) and (e), a corner block is shown in (f), and a sill block in (g).

Fig. 6 (a) shows a section taken vertically through several of these wall blocks, in which the double shells are at *b, b* and the webs at *a, a*. The mortar *c* is placed between the double shells only, and not between the webs at *d*. This breaks the continuity of these mortar joints. In (b) is a plan, in which the double shells are shown at *a* and *b* and the vertical webs at *c*. The air spaces between the ends of the blocks are at *d, d*, and the mortar joints between the ends of the tiles are at *e, e*.

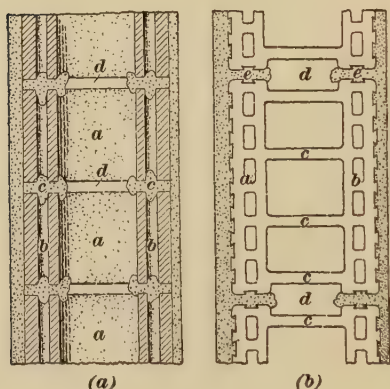


FIG. 6

block of tile, $8'' \times 12'' \times 12''$ tile being used for an 8-inch wall, $10'' \times 12'' \times 12''$ for a 10-inch wall, and $12'' \times 12'' \times 12''$ for a 12-inch wall.

Units of different thicknesses are often used in the same structure, since it is often desirable to make the wall in one portion of a building thinner than in some other portion, the upper walls of a building often being made thinner than the lower ones.

20. Method of Setting.—The regular, or box-shaped, forms of tile are generally set with the webs and cells in a vertical position so that the edges of the blocks are over each other on the outside and inside faces of the wall. The blocks

19. The bulk of the wall, when regular tile is used, is composed of standard units, each consisting of a cellular

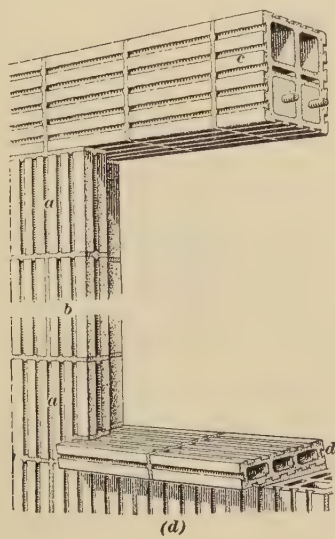
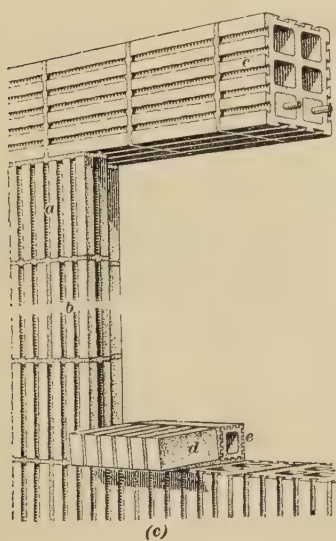
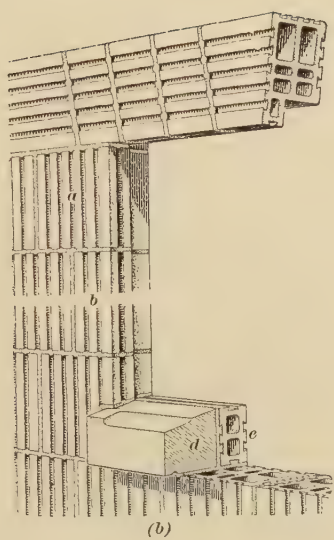
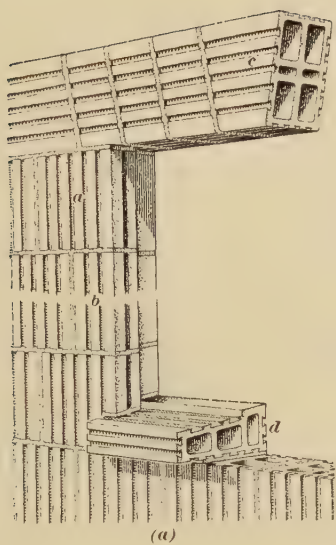


FIG. 7

are staggered over those below; that is, the vertical joint between two blocks is over the middle of the block below.

These tiles, set with the cells vertical, yield the maximum amount of strength. They are, however, sometimes set with the cells in a horizontal position, and for the ordinary loads that occur in dwellings, small factories, and other minor structures they are sufficiently strong when set that way.

21. The method of setting blocks with the cells vertical affords an easy means of forming chases for pipes and also allows of forming concrete piers beneath concentrated loads

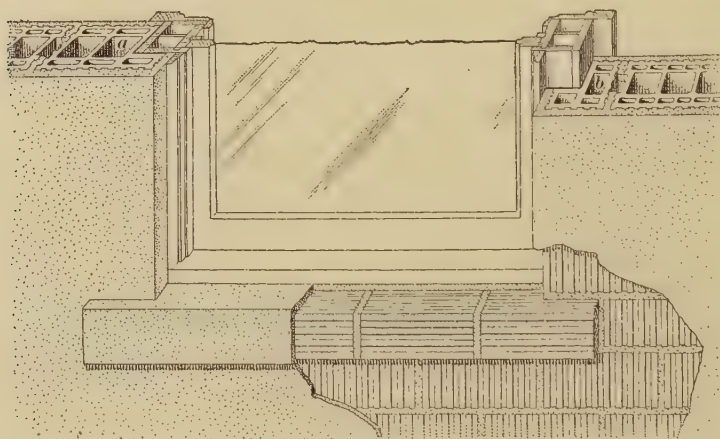


FIG. 8

that may occur in the structure. These concrete piers can be formed by simply filling a number of the cells below the special load with concrete, which sets and forms a strong vertical support, or pier.

Where the blocks are set with the cells in a horizontal position, it is difficult to cut chases and impossible to form special piers with concrete as just described. In such a case the chases must be formed as the wall is built, as will be described later.

22. Special Shapes.—There are several special shapes in hollow-tile blocks that are used in connection with the regu-

lar tile; some of these shapes are *jamb blocks*, *lintel blocks*, *sill blocks*, and *solid slabs*.

23. Jamb Blocks.—Jamb blocks, shown in Fig. 3, are used where box window frames are installed in a building. These blocks contain a rabbet into which the window frame is set. The use of jamb blocks and half jamb blocks is illustrated in Fig. 7, where at *a* are shown jamb blocks and at *b* half

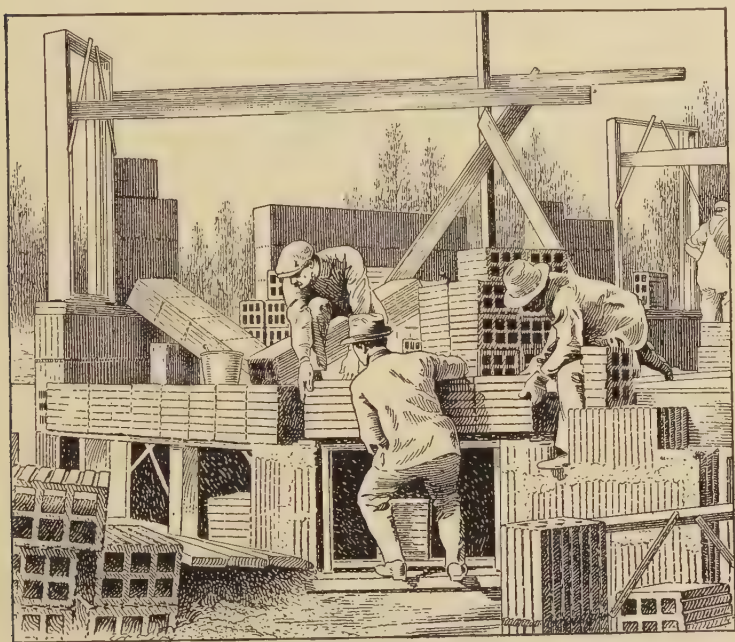


FIG. 9

jamb blocks, which are used alternately in the height of the wall in order that the wall blocks may break joints and also bond in strongly with the window jambs. Jamb blocks *a* and half jamb blocks *b*, for use in connection with the blocks shown in Fig. 5, are shown in Fig. 8.

24. Lintel Blocks.—Lintel blocks are used to form lintels over door and window openings that are not over 5 feet in width. One type of lintel block is made in the shape of a

voussoir, or arch stone, so as to form a flat arch as shown in Fig. 7 (a). Another form of block, shown in (b), also

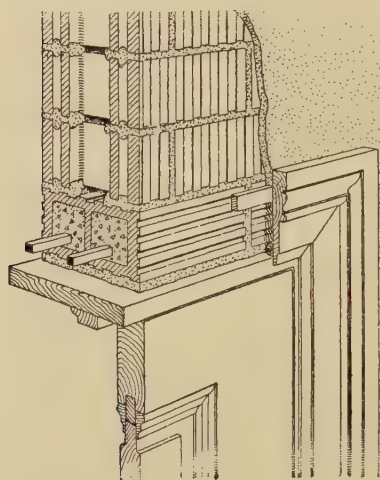


FIG. 10

forms a flat arch and has a rabbet *c* which is designed to receive the top of the window frame. The lintels most frequently used in practice are shown in (c) and (d), and consist of several standard blocks placed together as illustrated. These blocks are piled up on end, steel rods are placed in the cells that are to be the bottom ones when the lintel is in place, and these cells

are filled with concrete or strong mortar. The rods extend throughout the entire lintel and provide tensile strength for the bottom of the lintel. When the concrete or mortar has thoroughly set, the lintel may be lifted and set in place in the same manner as a stone lintel, as illustrated in Fig. 9.

A form of lintel used with the blocks shown in Fig. 5 is illustrated in Fig. 10.

25. Sill Blocks. —

Tile for window sills can be obtained in the form shown at *d* in Fig. 7 (a). This sill is made with a suitable wash and rabbet, and is grooved to hold a stucco coating. Another form of sill is shown at *d* in (d) and con-

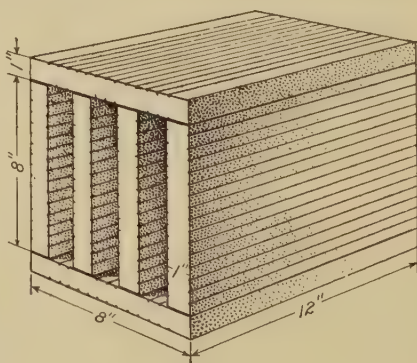


FIG. 11

sists of standard tiles 2 inches or 3 inches thick and laid either flat or with a slight slope. This sill is also designed to receive a coating of stucco. Other sills are used in connection with hollow-tile construction, such as the stone sill shown at *d* in (*b*) and the brick sill *d* in (*c*). The sill in (*c*) may be constructed of hollow terra-cotta tile of brick size, or of ordinary brick and covered with stucco; or it may be formed of face brick and show the brick surface on the finished sill. Stone or brick sills are sometimes backed with terra-cotta blocks, as shown at *e* in (*b*) and (*c*).

26. Solid Slabs.—Solid slabs, 1 inch in thickness, are made for use under beams. They are laid over the cells on top of the regular wall blocks to form a continuous bearing for floorbeams, as shown later. These slabs are delivered at the building in the form of boxes resembling the regular box tile, as shown in Fig. 11. When tapped on the corner, these blocks fall apart into 6 flat slabs. The sizes in which these slabs are made are 1 in. $\times$ 8 in. $\times$ 10 in.; 1 in. $\times$ 6 in. $\times$ 12 in.; and 1 in. $\times$ 8 in. $\times$ 12 in.

T-SHAPED TILE

27. Form and Use.—As indicated by the name, **T-shaped** tiles have a shape similar to that of the capital letter **T**, as is shown in Fig. 1 (*a*) and also in Fig. 12. This type of tile is laid with the cells in a horizontal position.

The particular advantages claimed for the **T-shaped** tile are, first, that the shape of the tile breaks the direct mortar joint between the outside and inside surfaces of the wall. This will be seen in Fig. 12, where in (*a*) is shown an 8-inch wall, in (*b*) a 12-inch wall, and in (*c*) a 16-inch wall. In all these walls it will be seen that the mortar joints *a* are interrupted by the air spaces *b*, so that moisture cannot penetrate through the wall by way of the mortar joints.

The second advantage claimed is that no air space in one course of tile communicates with air spaces in the next course above or below, hence there is less circulation of air than when the cells are placed vertically.

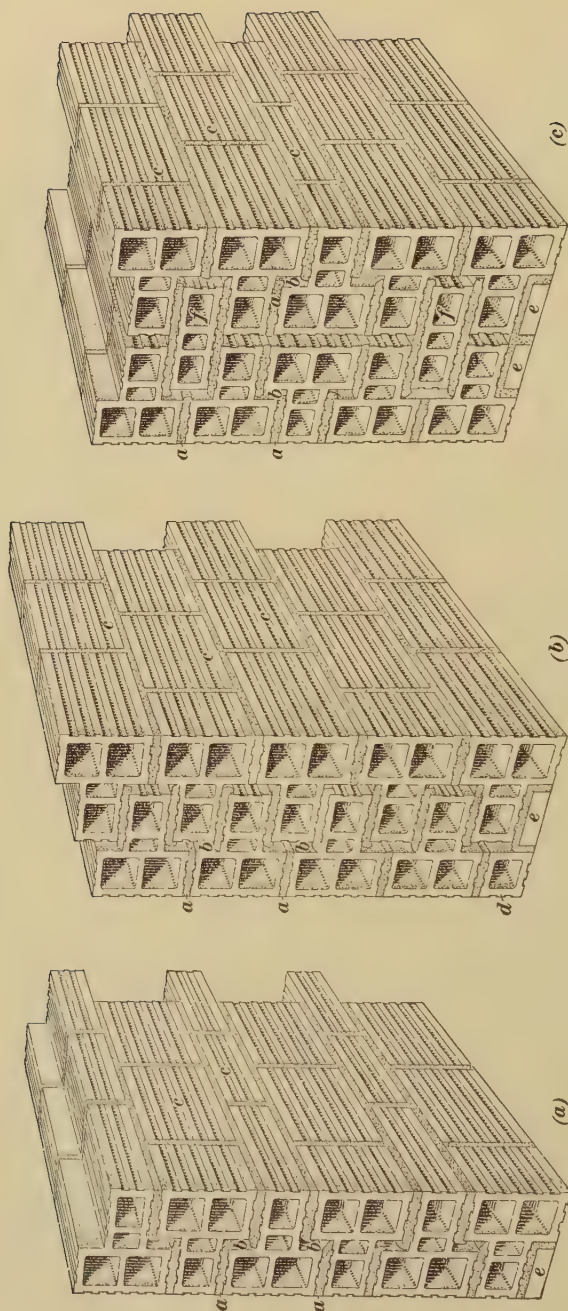


FIG. 12

As in the regular tile, the webs come directly over each other, thus forming continuous webs that carry down the loads supported by the wall to the footings under the wall.

In laying these blocks, the joints are staggered or broken, as shown at *c*, as is done in laying the regular blocks. In Fig. 1

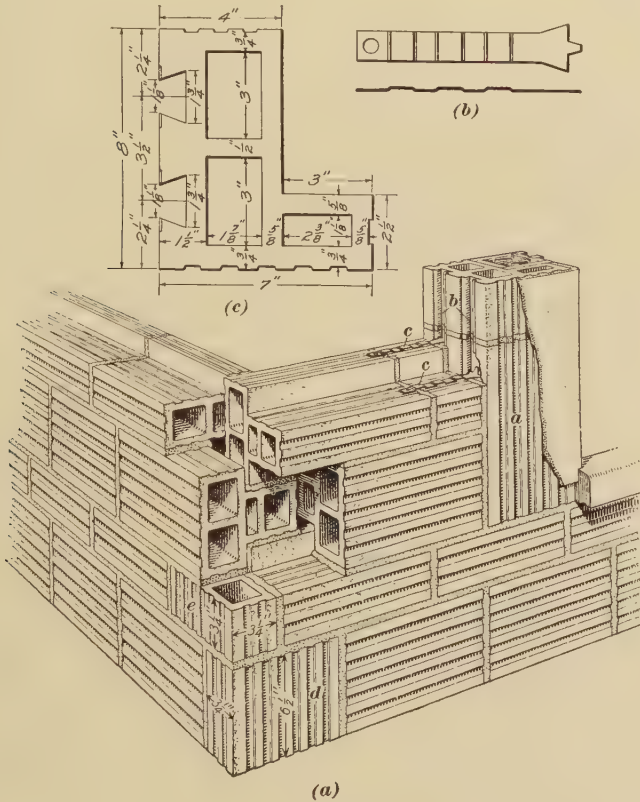


FIG. 13

(a) is shown a T tile with the standard dimensions. The standard tile is 12 inches in length, but some of the blocks are scored or indented so that they can be easily broken into 4-inch and 8-inch lengths when desired. This does away with the necessity of purchasing extra shapes for places in the wall where these shorter lengths are required.

28. Special Shapes.—As in the case of the regular tile, special forms or shapes are required when using **T**-shaped tile for the jambs of windows, where box frames are used, as well as for sills, lintels, corners, starting blocks, etc.

29. Jamb Tile.—The form of tile used for jambs in connection with **T** tile is shown at *a* in Fig. 13 (*a*). The large dovetail grooves *b* in the wall side of this tile are for the reception of steel anchors *c* which fit into the grooves as shown in

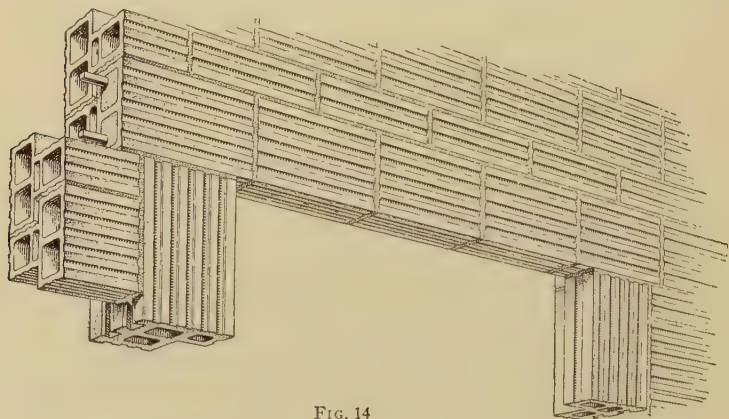


FIG. 14

the figure and tie the jamb blocks firmly to the wall. In (*b*) is shown a plan of one of these anchors. A plan of the jamb block is shown in (*c*).

30. Lintels.—Lintels are formed by piling the required number of wall tiles on end and filling the cells with concrete, steel bars first being placed in the cells that are to be the upper and the lower cells when the lintel is in place. When the concrete has set, these lintels are set in place in the same manner as stone lintels. It is not safe to use a lintel of this type for an opening more than 5 feet in width. An illustration of a lintel formed of **T**-shaped tile is given in Fig. 14.

31. Chases.—In walls, vertical chases for the accommodation of soil and steam pipes, etc. are made in the form shown

in Fig. 15, by using the standard **T** tile as far as possible and filling in with pieces of tile obtained by cutting the standard tile or with bricks. In (a) is shown a chase in an 8-inch wall, and in (b) a chase in a 12-inch wall. These chases are covered with wire lath as shown in (b), and the plastering is continued across the chase opening.

32. Corner Tile.

In building a wall of standard **T** tile there will always be certain spaces left at the corners of the wall that will require special-shaped tiles to fill them out properly. In Fig. 13 (a) is an 8-inch wall which shows the spaces left to be filled with special corner tiles after the regular **T** blocks have been used as far as possible. The blocks *d* and *e* in (a) represent the corner blocks required for this purpose. The smaller block *e* is merely one-half of a block such as *d*. The blocks *d* are $6\frac{1}{2}$ inches high and are scored or marked so as to be broken easily into two $3\frac{1}{4}$ -inch blocks when required. For 12-inch walls the same corner block as at *d* is used, as shown in Fig. 16 at *a* and *b*. These blocks are $6\frac{1}{2}$ inches in height and are used in both positions.

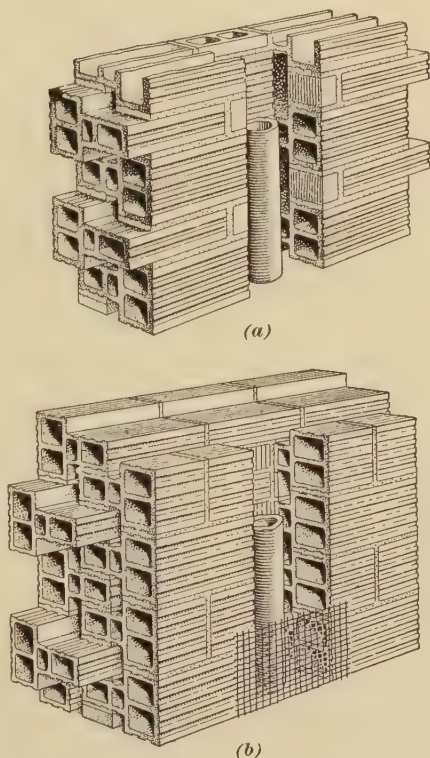


FIG. 15

33. Starting Blocks.—It is necessary in starting a **T**-tile wall upon a level surface to use starting blocks as shown at *d*

and *e* in Fig. 12. The block *d* is a one-celled block while *e* is a solid piece of terra cotta or brick.

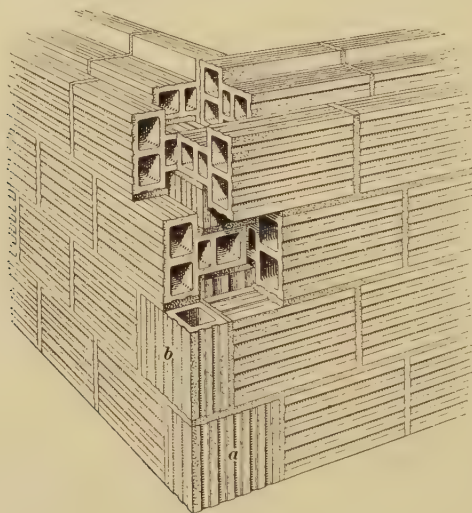


FIG. 16

34. Bonding Tile.—A special tile, shown at *f* in Fig. 12 (*c*), is required for walls 16 inches or more in thickness to complete the bond properly.

H-SHAPED TILE

35. Form and Use.—H-shaped tiles are also usually laid with the cells in a horizontal position, and the same advantages are claimed for them as for T-shaped tile. The H-shaped tile is illustrated in Fig. 17. At *a* in (*a*) is shown an $8\frac{1}{4}'' \times 10\frac{1}{4}'' \times 12''$ block. The height of this block, $10\frac{1}{4}$ inches, is the same as that of four bricks and three mortar joints; the block shown in (*b*) is $7\frac{5}{8}$ inches, or three bricks and two mortar joints, in height; that shown in (*d*) is $8\frac{1}{4}$ in. $\times 5\frac{1}{8}$ in. $\times 12$ in., or two bricks and one mortar joint in height. The block shown in (*c*) is about the size of a common brick but 12 inches in length.

The slots in the tops and bottoms of these blocks serve to break the mortar joint so that it will not be continuous through the wall. This is shown in (a) and (b).

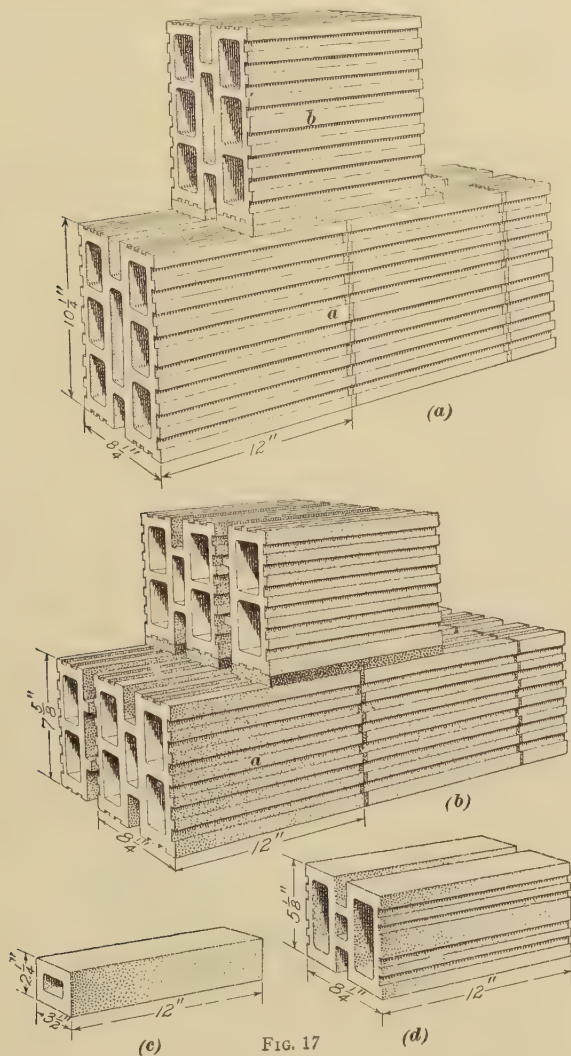


FIG. 17

In (a) is shown the method of laying the blocks in an 8 1/4-inch wall and in (b) in a 13-inch wall.

H blocks have four heavy vertical webs which come above each other in the successive layers of blocks and thus form continuous webs from the foundation to the top of the wall. The surfaces of these blocks are finished with deep grooved scoring, scratched scoring, or smooth.

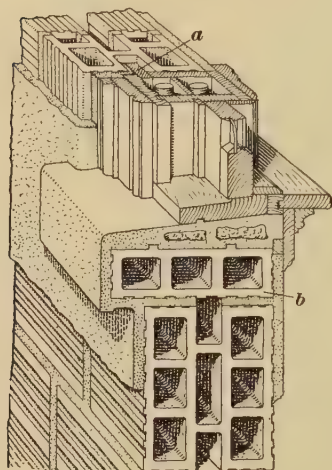


FIG. 18

36. Jamb Tile.—Jamb tiles may be formed by standing the regular **H** tiles with the cells vertical. A strip of wood is secured to the window frame and extends into the groove in the tile as shown at *a* in Fig. 18. This strip acts as a wind stop and also prevents the frame from falling out of the wall.

A special jamb block is made with full-size blocks as shown at *a*, Fig. 19, and half blocks *b*

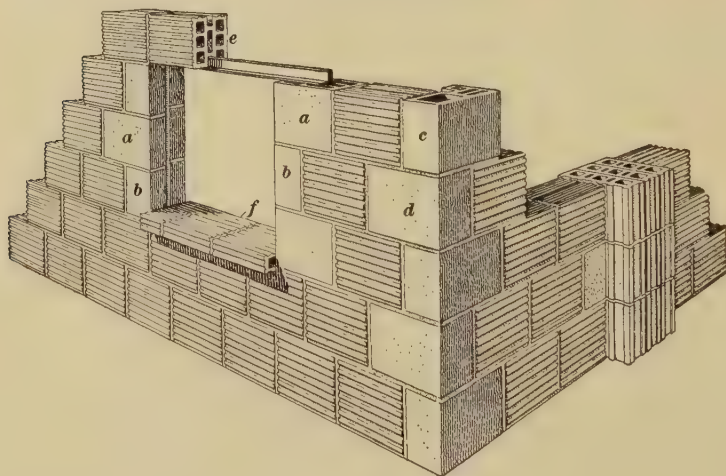


FIG. 19

which are used alternately in the height of the jamb. This block is also shown in plan in Fig. 20 (*a*).

A third kind of jamb block is formed by cutting away a portion of the regular block so as to form a rabbet, as shown in (b), Fig. 20.

37. Sill Tile.—For sills a three-celled block made by cutting a standard **H** block in two, is used as shown in Fig. 18 at *b* and in Fig. 19 at *f*. Brick or stone may also be used as with the regular tile.

38. Corner Blocks.—A special corner block shown at *c*, Fig. 19, is used to complete the corners of walls laid up with **H** tile. The application of this corner block is shown at *c* and *d*.

39. Lintels.

Lintels may be made with **H** tile in exactly the same manner as those in the regular block by piling up a sufficient number of blocks on end, inserting steel rods in the cells that will be at the bottom of the lintel when it is in place, and filling these with concrete. Lintels are also formed as shown in Fig. 19 at *e* by placing two steel angles back to back and setting standard tile on top of them.

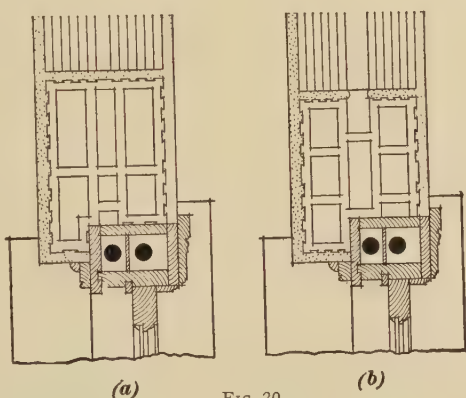


FIG. 20

SPECIAL TILE

40. Backup Tile.—A special type of hollow tile, called *backup* tile, is manufactured for use in backing up brick veneering. By its use a lighter wall can be built than would result if common brick were used for that purpose and one that is sufficiently strong to support the loads that are met with in moderate-sized buildings. Backup tiles are made 5 inches, or two courses of brick, in height, and are either 4 in. $\times$ 12 in.

or 8 in. $\times$ 12 in. in horizontal dimensions, so as to form either a 9-inch or a 13-inch wall with the brick veneering. The use of this form of tile is discussed later on in this Section and is illustrated in Fig. 38.

41. Silo Blocks.—Special hollow-tile blocks manufactured for the purpose of building silos are illustrated in Fig. 21.

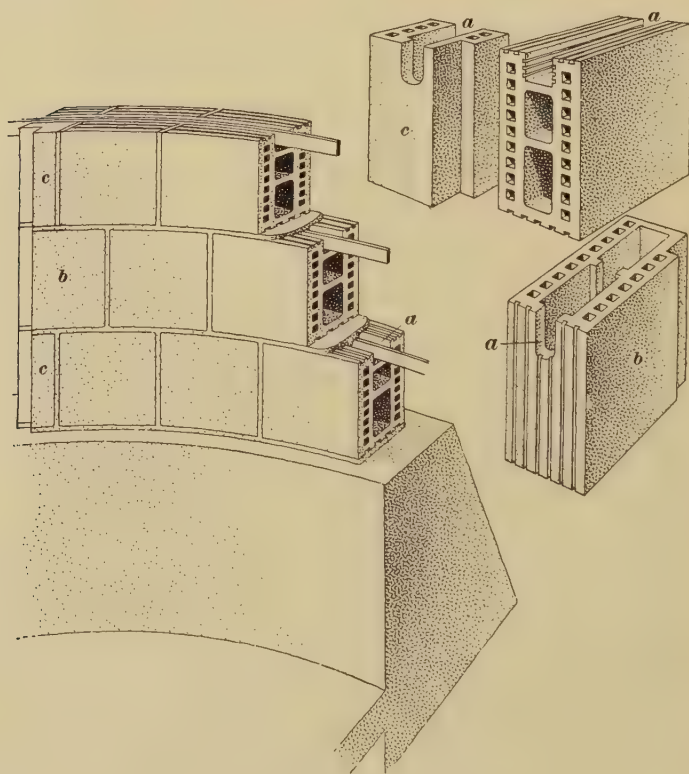
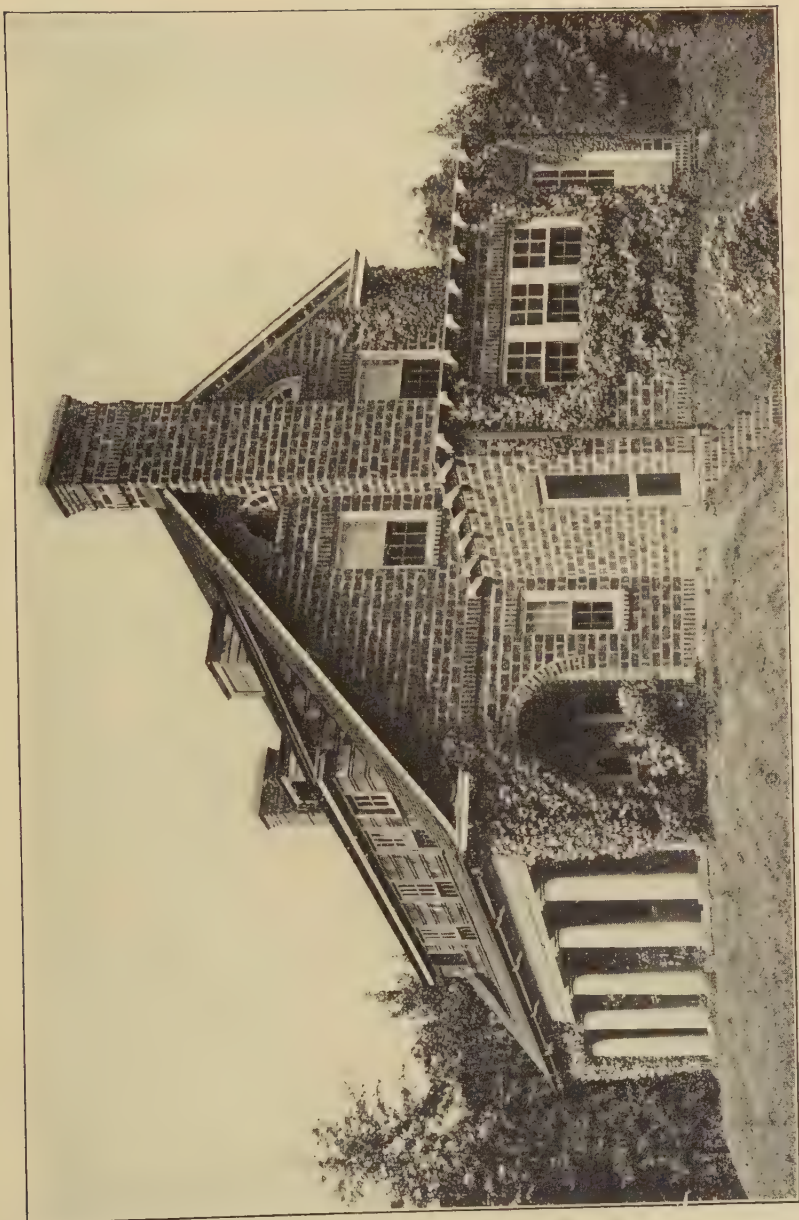


FIG. 21

The blocks are molded to a radius according to the diameter of the silo, and grooves *a* are formed in their upper edges into which iron or steel bands are set. The grooves are then filled with mortar. The purpose of the bands is to prevent the bursting of the silo which might be caused by the pressure of its



Courtesy of National Fire Proofing Co., Pittsburgh, Pa.

FIG. 22

contents. Hollow-tile blocks with which certain standard sizes of silos can be built are kept in stock by manufacturers, and promptness in delivery of the material can be obtained by ordering silos of such sizes.

The blocks are made of vitrified clay, which is fireclay or shale that has been burned until it has become vitrified. They are therefore very durable and are not porous. The size of the regular silo block is 6 inches thick and 12 in. $\times$ 12 in. on the outer face. Where the doors to the silo occur, special jamb tiles *b* and the half jamb tiles *c* are used.

42. Textile.—*Textile* is a form of hollow tile that combines the features of the hollow-tile blocks with those of face brick. The Textile block is a hollow-tile block in which the exposed faces are finished like a rough face brick. A wall built of these blocks has the advantage of being hollow and of having the color and texture of rough face brick where exposed on the outside. The exterior effect of this wall is distinctive, as the faces of the Textile blocks showing in the face of the wall are about three times the size of a standard brick, or about 12 in. $\times$ 5 in. The wall has the appearance of having been built of very large bricks, which gives it a peculiar attractiveness. Fig. 22 shows a charming house, built of Natco Textile blocks, which illustrates the effect of this unit. In contrast with the Textile blocks, the string-course, lintels, sills, and the arch, are built of standard-sized brick, which emphasize the size of the Textile block.

Fig. 23 shows a few of the standard Textile blocks. They are used in practically the same manner as other hollow-tile blocks. In (*a*) is a regular block for use in the body of the wall. The face *a* is finished like the surface of a face brick. The back of the block *b* is grooved to afford a firm grip for plaster. These blocks are placed with the cells in a vertical position. In (*b*) is shown a lintel block made by placing two, three, or more special blocks together end to end, inserting rods *b*, and filling the middle cells *a* with concrete. When the concrete has set, a lintel is formed similar to those made for regular tile and is set in place in a similar manner.

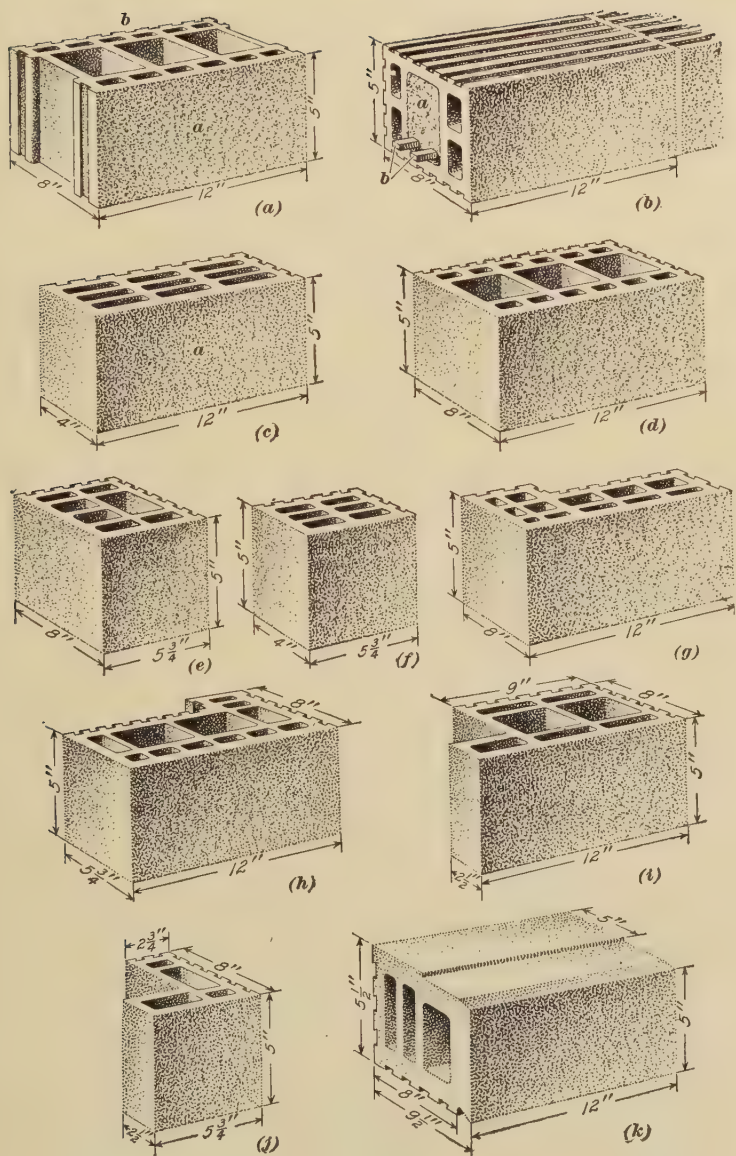


FIG. 23

In (c), (d), (e), and (f) are shown closures used in finishing jambs or sides of other openings in the tile wall that do not require to be rabbeted. Corner blocks are shown at (g) and (h), and jamb tiles at (i) and (j). A sill block is illustrated at (k). These various blocks are used in a similar manner to those already shown in the standard **T**-shaped and **H**-shaped tile. A study of the building shown in Fig. 22 will give a good idea of the method of using Textile blocks.

The shapes of these blocks are similar to those shown in Fig. 5, the difference being in the treatment of the outer face.

SURFACES OF TILE

43. Surface Treatment.—In addition to variations in shape or form, and in density, tile vary in the treatment given to their surfaces. These surfaces are formed according to the purpose for which the tile is to be used.

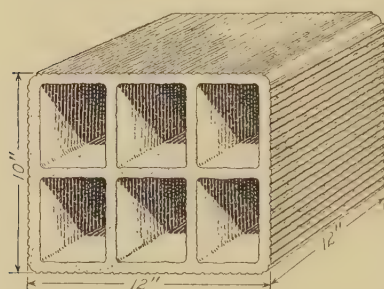


FIG. 24

The principal surfaces made on hollow tile blocks are *smooth*, *scratched*, *scored*, and *special* surfaces.

44. Smooth Surfaces.

Smooth-surfaced tile is, as the term indicates, entirely smooth, and is used most

often in building factories or warehouses where the tile is to be left in its natural state, uncovered by other materials such as stucco or face brick. Tiles are frequently made so as to present a smooth surface on one side only and are scratched or scored on the remaining surfaces. The smooth surface in this case is exposed.

45. Scratched Surface.—Scratched-surface tile is tile having its surface scratched as shown in Fig. 24 so that plaster and stucco will adhere to it more strongly. This surface is used also in walls that are to be faced with brick. Scratched-

surface tile is now so universally manufactured that it has become a standard type.

46. Scored Surface.—The scored surface is an exaggeration of the scratched surface and was designed primarily for walls that were to be plastered, the deep grooves providing an effective mechanical bond between the tile and the plaster. This style of surface is illustrated in Fig. 1. The scorings sometimes are plain rectangular depressions in the surface of the tile, and in other cases are dovetailed. The scored surface has also become a standard one, as it costs little or no more to manufacture than the scratched surface and forms an excellent bond not only for the stucco and plaster but for the mortar joints.

47. Special Surfaces.—Tiles are made with special finishes on the outside and inside for use where they are exposed on the finished surface of buildings and where ordinary smooth tile is not sufficiently attractive in appearance. These finishes are similar to those used on the surfaces of fine face bricks, and are used on the Textile blocks already described.

STRENGTH OF TILE

48. The strength of tile that is of interest to those using it in building is the compressive strength, or strength to resist crushing. This naturally varies with the hardness of the tile. The tile ordinarily used for wall blocks of any shape has a strength of about 5,000 pounds per square inch. This is the ultimate compressive or crushing strength. In practice only a fraction of this strength is estimated upon or employed, generally not more than one-sixth or one-eighth.

49. The building laws of Chicago require that the tile be "hard-burned terra-cotta tile of uniform quality, free from shrinkage cracks, with true beds, and having an ultimate compressive strength of not less than 4,000 pounds per square inch." The strength allowed in actual use is 500 pounds per square inch, or $\frac{1}{8}$ the ultimate compressive strength. These

figures refer to the actual terra-cotta material under compression, without regard to the cells.

50. The New York City building code estimates the compressive strength of tile blocks for the total area of the block, including shell, webs, and cell spaces.

Thus, a block 10 in. $\times$ 12 in. in horizontal section is considered as having a section of 120 square inches, and when tested must show an ultimate crushing strength of not less than 1,200 pounds per square inch when the cells are placed vertically and 300 pounds per square inch when the cells are placed horizontally. Hence the block just mentioned should show an ultimate strength of $120 \times 1,200 = 144,000$ pounds for the entire block, with cells vertical; or $120 \times 300 = 36,000$ pounds with cells horizontal.

The safe carrying capacity allowed by this code is 100 pounds per square inch with cells vertical, and 50 pounds per square inch with cells horizontal.

USES OF HOLLOW TERRA-COTTA TILE

51. Various Uses of Hollow Tile.—Hollow tile in its various forms is used for erecting walls, partitions, piers, columns, floors, and roofs, especially when a fireproof construction is desired. The form of hollow tile here under consideration is that which is designed for building exterior walls to support floors and roofs. Tiles for this purpose are designed with strong vertical webs for supporting such loads, and may be used in conjunction with fireproof floors of terra cotta or used in connection with floors of wooden construction such as those in frame houses.

52. Choice of Tile.—As in the case of other building materials, architects and contractors have their preferences for certain kinds of tile or tile construction, and it is well to be familiar with all the best kinds of tile and their uses so as to be able to choose intelligently among them. Excellent buildings have been erected by using each of the different kinds of tile on the market and by following the methods recommended

by tile manufacturers. The selection depends upon the tile that can be delivered most promptly or which is the best or the cheapest.

FOUNDATIONS OF HOLLOW TILE

53. In many buildings hollow tile is used for the foundation walls. When used for this purpose the tile should be vitrified or glazed, as ordinary hollow tile such as is used for walls above ground will disintegrate in time if placed underground. In this respect it is like common brick, which is not

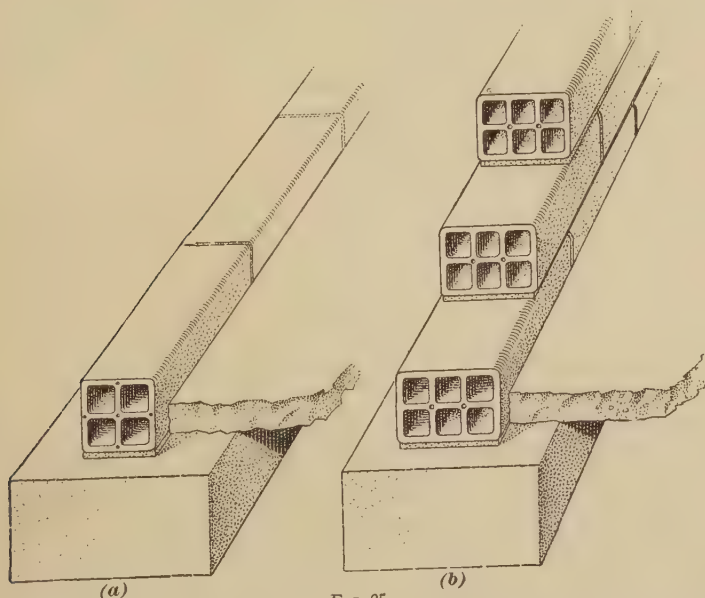


FIG. 25

the best material to use below the surface of the ground unless very hard burned or vitrified.

54. Dense-Tile Foundations.—Dense tile is used for foundations, but when so used it is advisable to protect it from dampness by coating the exterior of the wall with some waterproofing compound such as asphaltum or coal-tar pitch. Another way of protecting this kind of tile is to give the outer

surface of the walls a good coat of Portland cement stucco or plaster as is done in the case of brick foundations. The plaster should be composed of a mixture of 1 part Portland cement and 1 part sand, with not more than $\frac{1}{10}$ of a part of hydrated lime added.

55. Telephone-Conduit Tile for Foundations.

When it is desired to use foundations of hollow tile, ordinary telephone-conduit tile will be found to be very satisfactory both as to endurance and economy. This kind of tile is used for underground conduits by the telephone companies. The tiles are 9 in. $\times$ 9 in. and 9 in. $\times$ 13 in. in cross dimensions, and 18 inches to 36 inches in length. They are illustrated in Fig. 25. The 9" $\times$ 9" tiles laid flat form a wall 9 inches in thickness as shown in (a), and the 9" $\times$ 13" tiles form a 13-inch wall, shown in (b). The larger units contain 6 cells and the smaller units 4 cells. This material will be found strong enough to sustain the ordinary loads of a dwelling house or other small building. Conduit tile is glazed, presenting the same texture as ordinary glazed sewer pipe, and will last for an indefinite length of time underground.

56. Telephone-conduit seconds are conduit tile with slight imperfections in finish, such as blisters or broken edges, and are often slightly warped. They are not satisfactory for the purposes of telephone conduits, but are perfectly useful for building foundation walls below grade. They are also much cheaper than perfect conduits, thus making them economical to use as foundation material.

57. Laying Conduit Foundations.—Telephone-conduit tile should be laid in full beds of cement mortar, and any corners that are broken should be patched with mortar. At the corners of the wall where the openings of the cells appear on the face of the wall, the ends of the cells should be closed up with brickbats and mortar.

58. Building-Code Restrictions.—The building laws of some cities make restrictions as to the use of terra-cotta hollow tile for foundations. Thus, the building code of New

York City specifies that hollow blocks may be used for foundation walls only when the upper walls are of frame or hollow building-block construction; also that the hollow spaces in the blocks shall be filled, as the construction progresses, with concrete consisting of not less than 1 part of cement to 9 parts of aggregate. Other cities require that buildings erected with hollow terra-cotta tile walls shall not be over four stories in height.

59. Other Foundations Used With Hollow Tile.

In many sections of the country, cement concrete, concrete blocks, and stone are of no greater expense than hollow tile and are consequently used for foundations instead of hollow tile, even though the upper walls are to be built of tile.

In a house or small building, where the exterior walls above grade are to be 12 inches in thickness, a 12-inch foundation of concrete blocks or of solid concrete is usually sufficient.

Where the upper exterior walls are of 8-inch tile, a 12-inch foundation wall should be used. These thicknesses are for cellar walls that extend 6 or 8 feet into the ground.

EXTERIOR WALLS OF HOLLOW TILE

WALLS OF REGULAR, OR BOX-SHAPED, TILE

60. Wall Construction.—Illustrations of the individual tiles of box shape used in building walls have been shown in Figs. 1 (*c*), 2, 5, etc. Walls can be built of these blocks in various thicknesses, such as 6 inches, 8 inches, 10 inches, and 12 inches, by making the walls one block in thickness, as illustrated in Fig. 26 (*a*), (*b*), and (*c*). Thicker walls, which, however, are rarely called for, can be formed by combining these units in different ways so as to provide a sufficient bond, as shown in Fig. 26 (*d*). These blocks have a uniform height of 12 inches, but blocks of different sizes can be supplied by the manufacturers if necessary, as where the heights of the different stories of the building do not work out evenly by the use of

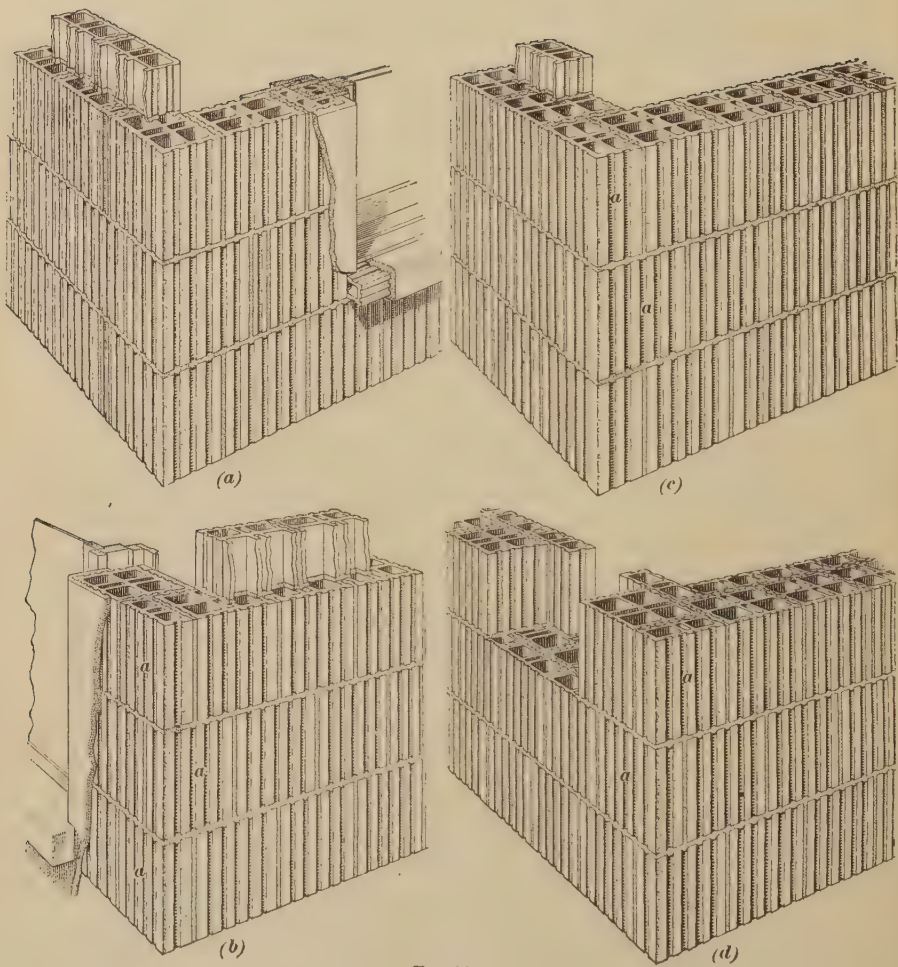


FIG. 26

blocks 12 inches high. It is an excellent plan when ordering hollow tile to send a set of plans to the manufacturer, who will then be able to ship exactly the right assortment of sizes of blocks.

As a wall is rarely required to have the same thickness for its whole height, the wall in the different stories can be made of different thicknesses. Thus, the cellar wall may be made 12 inches in thickness by using 12-inch blocks, and the first-story walls 8 inches thick by using 8-inch blocks. The second-story walls can be made 6 inches in thickness by using 6-inch blocks.

The New York building code requires that where the walls are reduced in thickness, the blocks on the top course of the

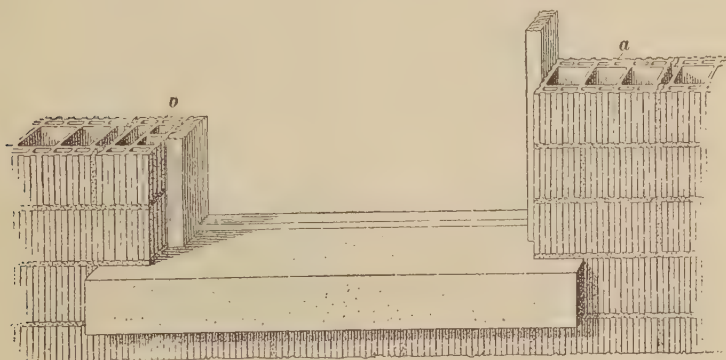


FIG. 27

thicker wall shall be filled solidly with concrete or covered with slabs of hard-burned terra cotta or concrete at least 1 inch in thickness.

61. Blocks of the kind shown in Fig. 5 are placed in a wall in the manner shown in Fig. 27, in which can be seen the construction around a door opening, a closure block being shown at *a* and a half closure block at *b*. A window opening is shown in Fig. 8 with a jamb tile at *a* and a half jamb tile at *b*; the construction of the sills is also shown. In Fig. 10 is shown a treatment for a lintel over a window opening.

62. Bedding in Mortar.—The bedding of tile, that is, the way in which tile blocks are set into the mortar, is a very

important feature of hollow-tile construction. Although different manufacturers claim that their particular forms of hollow tile offer advantages in bedding, bedding is really a matter of good workmanship. Any of the various patterns of tile that have already been described may be well laid if the workman understands the method and desires to do a good job. A good bed of mortar should always be placed beneath the

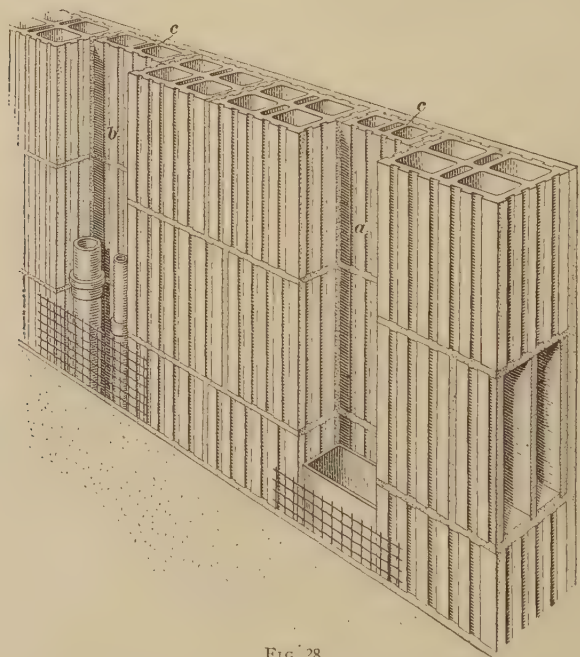
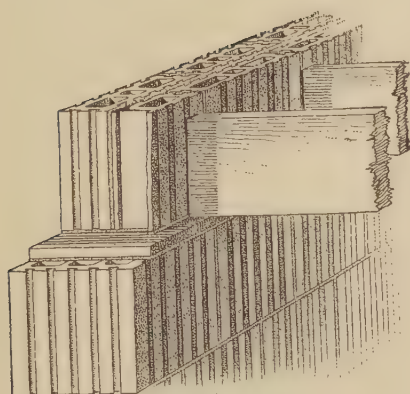


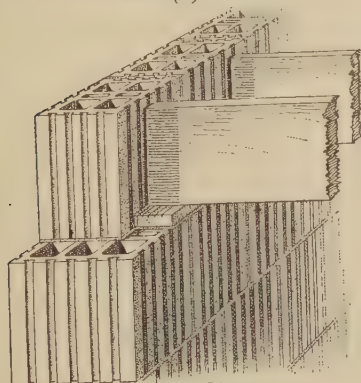
FIG. 28

bearing surfaces and in the vertical joints at both faces, but it is also desirable that the mortar joints should not be continuous through the thickness of the wall.

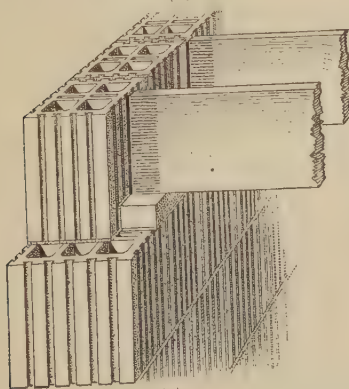
63. Mortar.—The best mortar to use in bedding hollow tile is a mortar made of 1 part Portland cement and 3 parts of clean sand to which $\frac{1}{10}$ part hydrated lime may be added. The mortar should be made stiff enough to adhere readily to the thin edges of the tile.



(a)



(b)



(c)

FIG. 29

64. Cutting Tile.

Terra-cotta tile can easily be broken with a mason's trowel or a hammer in the same manner as brick is broken. It can, therefore, be cut to fit special positions where there are no stock tiles of the proper size and shape on hand.

65. Chases. —

It is generally necessary to accommodate pipes, such as plumbing, heating, and gas pipes, as well as electric-wire conduits, within the thickness of the wall. Chases, or vertical recesses, must therefore be formed either by building recesses in the wall or cutting them in the wall after it is built. One of the advantages claimed for the regular tile is that chases can be cut wherever necessary after the wall is completed. It is not advisable, however, to allow the plumber, the gas-fitter, the heating contractor, and the electrician to hammer out chases in the wall wherever they may choose, hence it is better to build chases into the wall at properly designed points so as to accommodate all

the necessary pipes. Fig. 28 illustrates the method of building chases so that it will not be necessary to ruin the wall with a hammer. The wall at *a* and *b* is made thinner by using thinner blocks *c*, these blocks extending the full width of the chases. Over the chases, strips of wire lath are secured which close the chases entirely and afford a base to receive the plastering. Chase *a* accommodates a heating flue, and chase *b* a soil and a waste pipe.

66. Corner Blocks.—With the regular tile the problem of finishing the corners of a wall is easily solved by the use of regular stock blocks such as shown at *a* in Fig. 26 (*b*), (*c*), and (*d*), and the manufacturers generally send a sufficient quantity of these corner blocks to complete the wall. It is a great advantage to send a set of plans to the manufacturer when ordering, as he will then supply all the special pieces that may be needed to complete the job.

67. Supports for Wooden Floorbeams on Regular Tile.—Where wooden floorbeams are used, they naturally rest on the wall at each end, and the wall should be built so as to provide a suitable bearing for them. As a rule, the wall diminishes in thickness at the level of the floorbeams so that a shelf is formed by the projection of the lower wall beyond the upper wall, and upon this the floorbeams generally rest, as shown in Fig. 29. Where the difference in the thickness of these walls is 4 inches, a sufficient bearing is afforded for the average wooden joist, and flat tiles as in (*a*) and (*b*) or a row of bricks as in (*c*) is laid on top of the 4-inch projection. Upon these tiles or bricks the ends of the joists are placed.

Where there is a difference of only 2 inches in the thickness of the walls or where the walls of both stories are carried up at the same thickness, it becomes necessary to extend the ends of the joists into the upper-story walls so as to obtain at least a 4-inch bearing. This condition calls for a special arrangement of the tiles at the level of the joists, as illustrated in Fig. 30.

In this figure the joists are shown bearing upon a 1-inch flat slab *a* that is carried entirely through the wall. This affords a

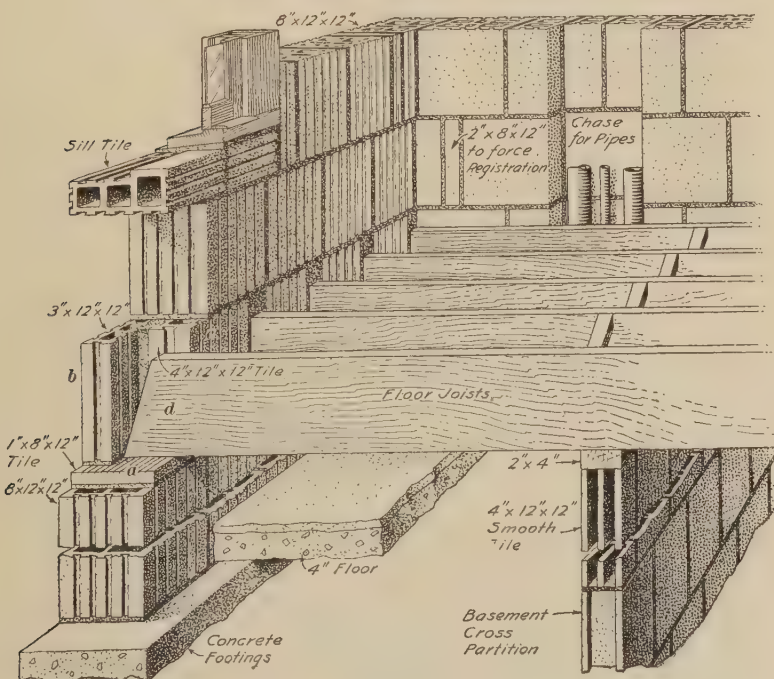
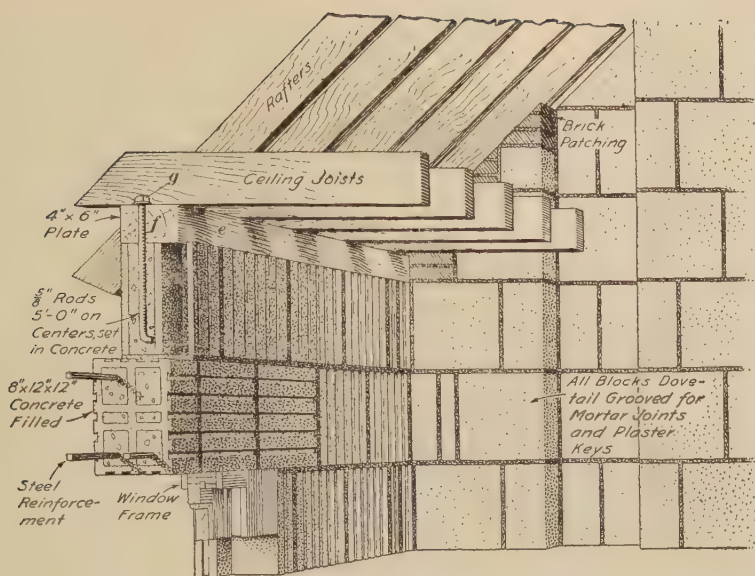


FIG. 30

flat bearing for the ends of the joists. Between the ends of the joists and the outside of the wall a row of thinner wall tiles *b* is placed and a second row of tiles *c* is placed between the beams. These two rows together form a base upon which the wall above rests.

68. A method that is sometimes used for supporting wooden floor joists is shown in Fig. 31 in which the joists are suspended by means of steel joist hangers *a*, which are in turn supported upon flat 1-inch slabs *b*. An advantage in this method is that the trouble of fitting the tile around the ends of the joists is avoided.

69. Anchoring Wooden Floor Joists.—The ends of joists when projecting into a tile wall should be cut with a *fire cut*, as shown at *d*, Fig. 30. This cut is so called because it permits the beam to fall out without injuring the wall if the timber should be burned off.

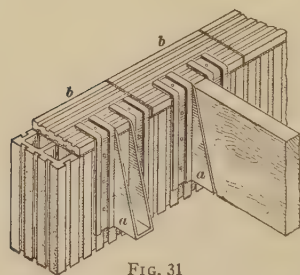


FIG. 31

Every fourth joist should be anchored to the wall by means of a wrought-iron rod, strap, or *dog*, driven into the top of the joists and built into the masonry. The purpose of these anchors is to tie the floors to the walls, and thus give greater stability to the building. Walls parallel to floor joists should be anchored by metal straps nailed to three or four joists and turned up into the wall.

70. Supporting Fireproof Floors on Regular Tile. The several forms of fireproof flooring used in connection with hollow-tile construction will be described and illustrated later, but the provision that must be made in the walls to receive the floors will be described at this point.

The floor systems mostly used in connection with hollow-tile construction are the flat concrete slab, the combination floor of hollow tile and reinforced concrete, the Johnson system, and the New York wire-truss system; and they all require that the

bearing walls supporting them have a flat tile placed over the ends of the cells to receive the floors. These floors extend to within 4 inches of the outside of the tile wall and a 3-inch facing tile is placed as shown at *a* in Fig. 32. At *b* is shown the flat bearing tile on which rests the floor system *c*, the weight of which is thus transferred to the bearing wall *d*. The upper-story wall *e* is started directly on the floor construction, as shown in the figure. In Fig. 33 the floor construction is shown resting on the lintel over an opening.

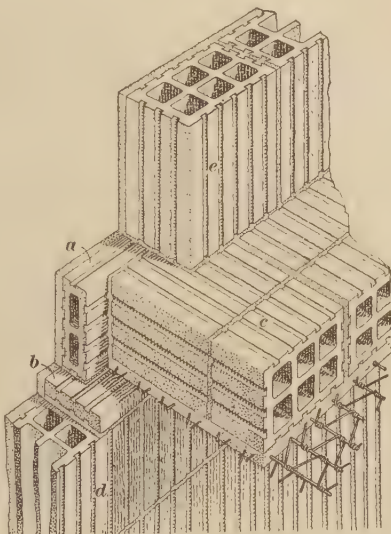


FIG. 32

71. Concentrated Supports.—In the floor

systems that have been mentioned the load is distributed over the bearing walls quite uniformly and does not necessarily bring any concentrated load on any particular point in the wall. Where steel girders are used, concentrated loads occur at the bearings of these girders, and the wall must be especially strengthened at these points. This is done by filling the cells of the tile with concrete for two or three courses below the bearing of the beam, or even down to the footings, to form a solid masonry pier under the load. Where the cells of the tile are in a horizontal position, a brick pier is sometimes built extending down for several tile courses and spreading out toward its lower part. This distributes the load over a large area of wall below.

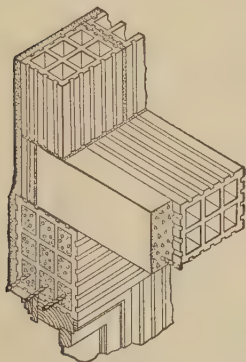


FIG. 33

72. Supporting Non-Fireproof Roofs on Regular Tile.—Flat non-fireproof roofs are supported in the same manner as non-fireproof floors; that is, the rafters, being flat, are supported in the same manner as floor joists. Where the roof pitches, the lower ends of the rafters are supported, as shown in Fig. 30, on a plate *e* which is anchored to the wall so that it will not be pushed off by the thrust of the rafters,

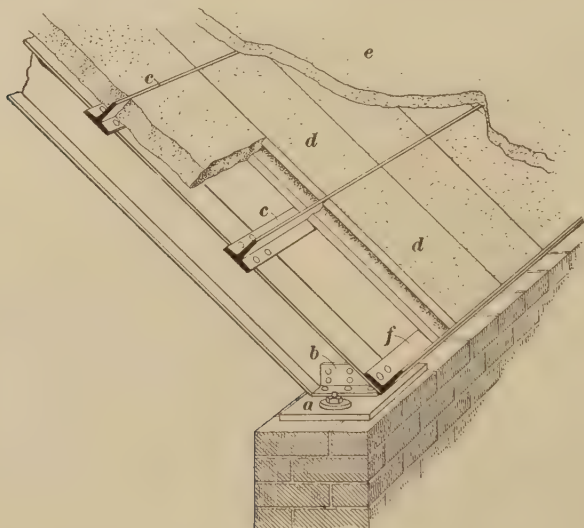


FIG. 34

although as an additional safeguard the lower ends of the rafters are generally tied together by means of the attic-floor construction. The anchors *f* consist of bolts which extend down into the wall, either through the blocks or between them, and also extend above the plate so that nuts and washers *g* can be used to hold the plate in position.

73. Supporting Fireproof Roofs on Regular Tile. As a matter of fact, it is unusual to build fireproof roofs on dwellings. Generally the houses are built fireproof up to and including the attic floor, a timber construction is used for the roof, and this is covered with a fireproof covering or roofing, such as slate, tile, or asbestos shingles, so that the roof itself will not catch fire from without.

As in the case of the non-fireproof construction, flat roofs of fireproof construction are similar to the floors in their design.

For pitched roofs of fireproof construction the same principles are used as in non-fireproof construction. As shown in Fig. 34, a metal plate *a* is anchored to the wall by bolts built into the wall and extending up through the plate so that a nut may be screwed on the top of the bolt to hold the plate in position. The rafters, which are generally **I** beams, are anchored to the plate as shown at *b*, and **T** irons *c* and an angle iron *f* are secured to the rafters at such a distance apart as to take the

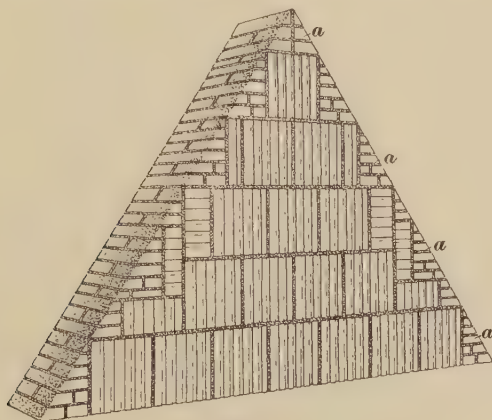


FIG. 35

tile *d* called book tile. A layer of cinder concrete *e* is then placed over the book tile and the roofing is nailed to it.

74. Pitched roofs may be made of the combination construction used for floors, which is described later on. This construction is exactly the same as a floor set on a slope. It is an expensive construction and is used only on elaborate work.

75. Finishing Gables.—In building gable walls of hollow tile it will be found wasteful to cut the blocks to a triangular shape to fill in the spaces *a*, Fig. 35. These triangles are therefore generally filled with brickwork as shown in the figure.

WALLS OF H TILE

76. The shapes of **H** tile have already been shown. The sizes are 12 in. $\times$ 8 $\frac{1}{4}$ in. horizontally, and 5 $\frac{1}{8}$ in., 7 $\frac{3}{8}$ in., and 10 $\frac{1}{4}$ in. vertically. The vertical heights, plus the thickness of one mortar joint, correspond to two, three, and four courses of common brick with the necessary mortar joints. A single block makes a wall 8 $\frac{1}{4}$ inches thick. When a 13-inch wall is required, the thickness is made of one 8 $\frac{1}{4}$ -inch tile and a half tile. These half tiles are made and carried in stock but may also be obtained by simply splitting the whole tile. The half tiles in such a wall are placed on the outside and the inside of the wall in alternate

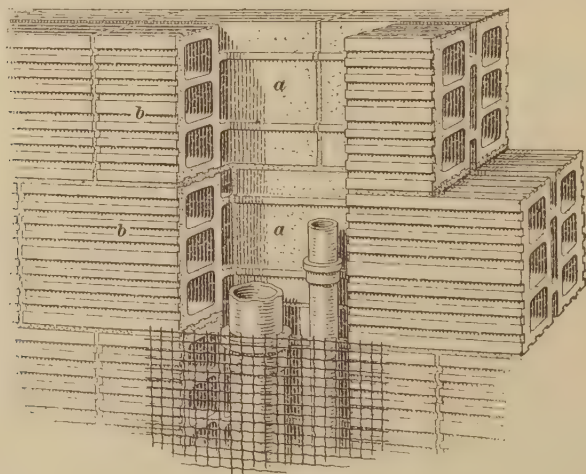


FIG. 36

courses as shown in (b) in Fig. 17. It will be noticed in this figure that the horizontal bed of mortar is broken into 3 parts so that it is not continuous through the wall.

77. Supporting Floors on H Tile.—Floor joists of wood are supported directly upon the upper surface of the blocks. The joists extend into the wall so as to bear upon two lines of vertical webs. The spaces between the ends of the joists are filled with 4 $\frac{1}{8}$ -inch tiles, which are the standard blocks split in two. Fireproof floors are supported in the

same manner, but such floors must be carried to within about 4 inches of the outer face of the wall so as to have as large a bearing as possible.

78. Supporting Plates.—The plates for supporting the lower ends of roof rafters on **H**-tile walls are secured in the same manner as on brick walls or walls of regular tile. Bolts are built into the wall so as to extend down about 16 or 18 inches and also to project through the top of the plate and receive a nut.

79. Finishing Gable Walls.—The triangular spaces in gable walls are finished in the same manner as for regular tile, as shown in Fig. 35 at *a*.

80. Chases.—Chases may be formed by the use of blocks of half thickness, as at *a*, Fig. 36, and bonding them into the full-thickness blocks *b*.

WALLS OF T-SHAPED TILE

81. T-shaped tiles are laid up in the wall as shown in Figs. 12, 13, 14, 15, and 16. In the 16-inch wall in Fig. 12 (*c*), a special tile *f* is required to complete the bond properly. Walls of other customary thicknesses, however, can be built with the regular **T**-shaped tile. A solid block of special shape is required to start the wall at the bottom, as shown at *e*, Fig. 12 (*a*), (*b*), and (*c*).

Jamb blocks are placed on end at each side of the opening, and must be securely anchored to the wall as shown in Fig. 13. Corner blocks of two different heights, as shown in Fig. 13 at *d* and *e*, are required to finish the corners properly. Chases are built as shown in Fig. 15.

Floors and roof plates are supported in the same general way as is done in **H**-tile walls.

VENEERED WALLS

82. By veneering the outer surface of a hollow-tile wall with brick, the advantages in appearance due to the brick facing, and of the air spaces and lightness due to the hollow-tile construction, are both secured.

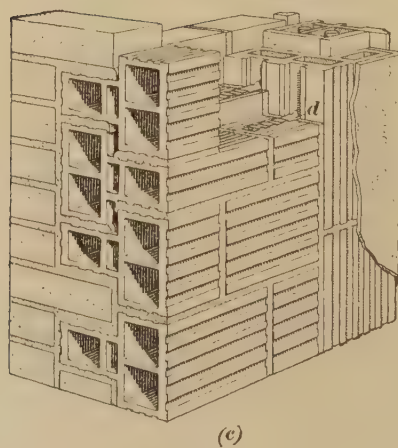
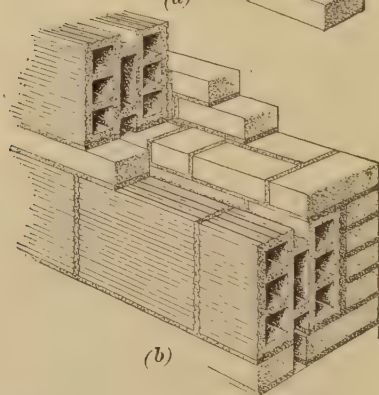
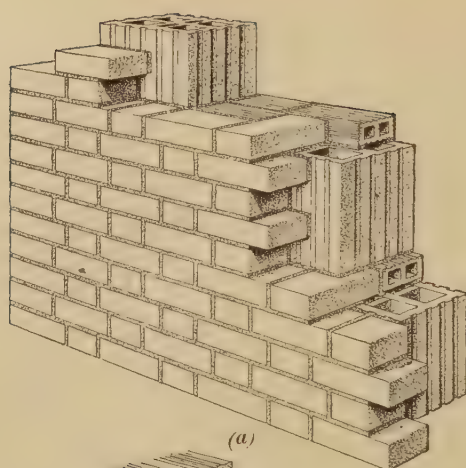


FIG. 37

The principal problem in constructing a brick-veneered wall is the bonding of the brick face securely to the tile backing. The various types of tile mentioned are designed so that this bonding may be readily accomplished. In Fig. 37 are shown the methods of tying or bonding the brickwork to the tile work

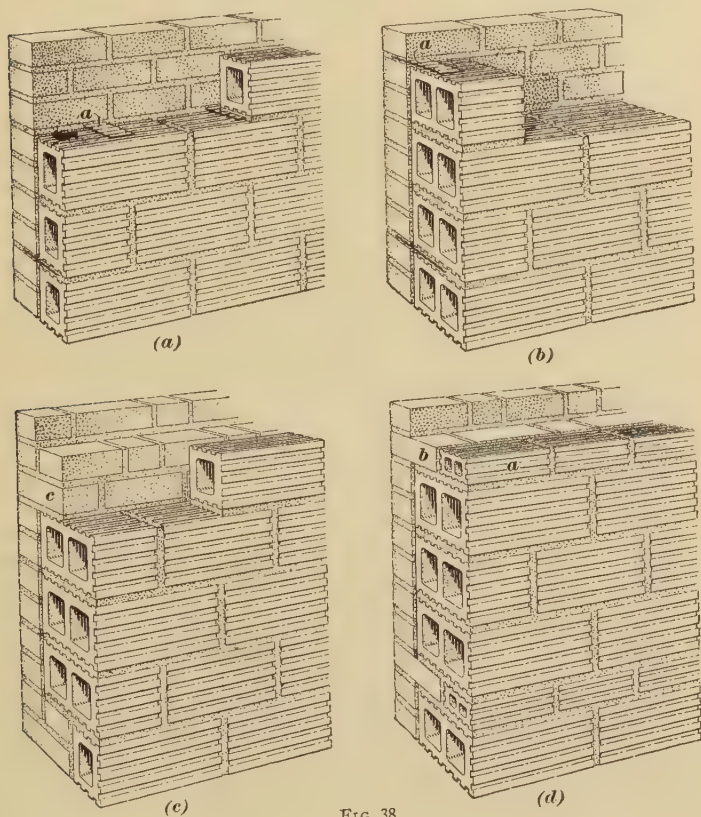


FIG. 38

of the three types already described. In (a) is shown the method used with the regular tile; in (b) and (c), with **H** tile and **T** tile. When it is desired to show no headers in the brick facing it is necessary to tie it to the tile with metal ties, in the manner shown at *a* in Fig. 38 (a) and (b). When brick-veneered walls are used, it is a frequent custom to use solid

stone sills and lintels for the window openings as well as stone string-courses, as is done in a brick building with solid walls.

83. Backup Tile.—A special type of hollow tile, called *backup* tile, is manufactured for use in backing up brick veneering. By using this tile a very light and economical wall can be built. The *backup* tiles are made with one face smooth for use in places where it is not desired to plaster the interior face of the wall. These tile are sometimes called "*Jumbo*" brick.

Where the brickwork shows only stretchers on the face, the bond to the backing is made by using metal wall ties as shown



FIG. 39

at *a* in (*a*) and (*b*), Fig. 38. Where, however, heading courses of brick are used, headers can extend into the wall as shown in (*c*) and (*d*). By using hollow-tile brick, as shown at *a* in (*d*), only one course of face brick is needed in forming the bond instead of two courses as shown in (*c*).

Fig. 39 illustrates a method of laying up a wall consisting of a brick-veneered face, backup-tile backing, and metal ties.

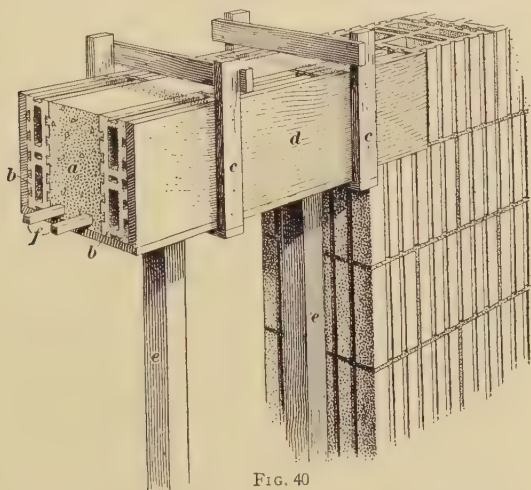


FIG. 40

Two of these ties are shown projecting from the back of the face-brick veneering between the hands of the two men.

OPENINGS IN WALLS

84. Openings.—Openings in walls are generally for doors and windows. The blocks that are used around such openings, such as lintels, jambs, and sills, have been illustrated.

The lintels are the only blocks that vary with the width of the opening. Lintels have been shown for spans of not over 5 feet. For lintels of a greater span than 5 feet, reinforced concrete or steel must be depended upon.

In Fig. 40 is shown a lintel which consists of a reinforced-concrete beam *a* faced with hollow tile *b*. The concrete beam is designed to carry all the load coming from the wall above the opening as well as from floor-beams that may rest on this wall.

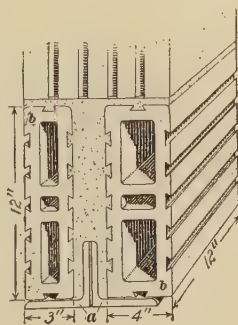


FIG. 41

The lintel is faced with thin blocks of hollow tile, which afford a better surface for stucco and plaster than the concrete surface would. These tiles adhere strongly to the concrete lintel, as the concrete flows into the dovetail grooves when the lintel is cast.

A lintel of this type is generally cast in position. The lintel shown in this figure is made in a wooden form, as shown at *d*. This form must be strongly supported by the struts *e*, and its sides must be braced as shown at *c*, so that they will not spread

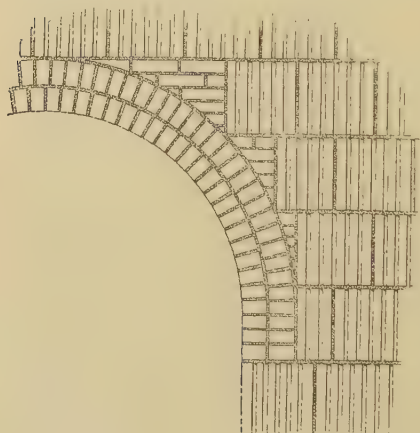


FIG. 42

apart when the concrete is cast in place. The tiles *b* are first placed in position and the rods *f* are set so that they will be about 1 inch above the bottom of the lintel. The concrete is then poured into the space *a* and allowed to set for a few days until it has attained considerable strength, when the forms may be removed.

A lintel that requires no forms and that will be ready to bear the load within a day or so is shown in Fig. 41. This lintel is virtually a steel lintel formed of two angles *a*, upon which terra-cotta blocks *b* are set, and concrete or cement mortar is filled in between them. The strength of this lintel is that of the two steel angles.

85. Arched Openings.—Arched openings in hollow-tile walls are made by using either plain bricks in the form of row-lock arches as shown in Fig. 42, or by using hollow-tile blocks as voussoirs, or arch blocks, as shown in Figs. 43 and 44.

In the arch shown in Fig. 42 the rectangular tile blocks are not cut to fit the triangular spaces, as brickwork is used to fill up these spaces, as shown.

COLUMNS AND PIERS

86. Columns.—Many designs for hollow-tile houses require round columns in such places as the front entrance or



FIG. 43

on porches. Manufacturers make a *radius tile*, or tile molded with a curved surface, such as shown at *a* in Fig. 45, which can be laid up to form cylindrical columns of different diam-

eters. When these columns are expected to support an extra-heavy weight the interior of the cylinder is filled in solidly with concrete *b*, which is sometimes reinforced with rods or bars *c*.

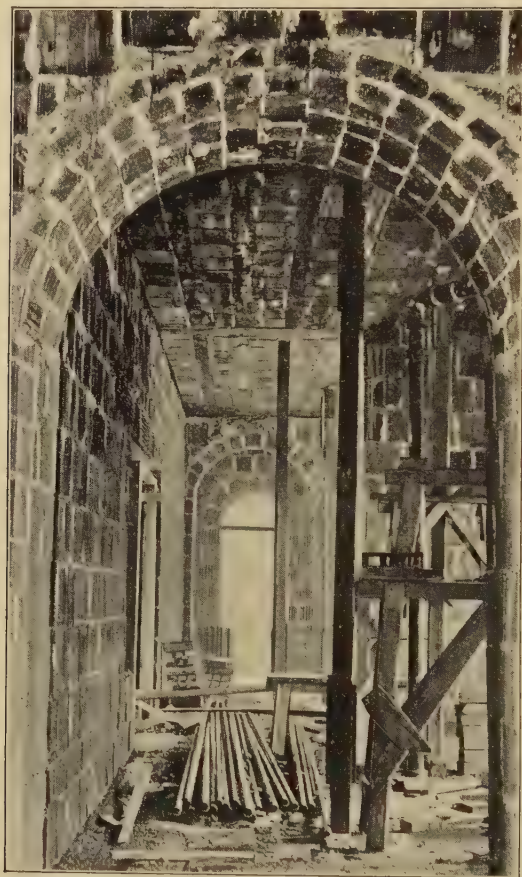


FIG. 44

Columns of this description are practically reinforced-concrete columns and will support loads in proportion to the diameters of the concrete cores. The enclosing tile is generally scored on the outside so as to hold a finishing coat of stucco.

87. Piers.—Piers, as shown in Fig. 46, can be built of stock-size blocks, which must be set up so as to break joints in

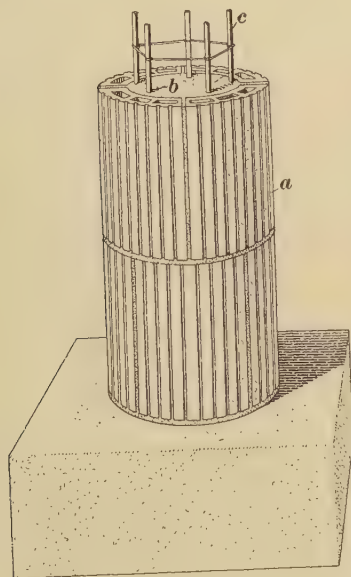


FIG. 45

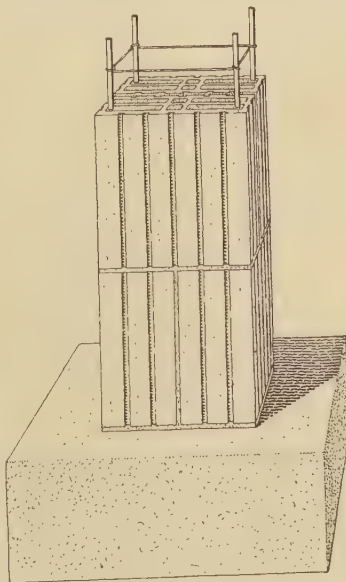


FIG. 46

alternate courses. These piers should be filled with concrete when supporting heavy loads. Reinforcing rods may be added as shown where greater strength is required.

ATTACHING FURRING, TRIM, ETC. TO WALLS

88. Use of Wooden Laths.—Many architects prefer to fur the interiors of all external walls of hollow-tile construction, as this provides space between the tiles and the plaster for gas and water pipes and electric conduits. It also affords a means of preventing cold striking through the walls to the plaster and causing moisture to condense on the face of the plaster. When the use of furring is contemplated, wooden laths are often built into the horizontal joints between the tiles at proper distances apart to afford nailing for the furring strips. This is illustrated in Fig. 47 at *a*,

89. Metal Wall Plugs.—Another good method of providing nailing for wooden furring is to use metal wall plugs, shown at *b* in Fig. 47. These plugs are small bent corrugated plates of metal that are set in the mortar joints while the wall is being built, and receive and hold nails driven into them through the furring strips as shown in the illustration.

90. Self-Clinching Nails.—Self-clinching nails may also be used for fastening wood to tile. These nails, shown in Fig. 47 at *c*, are driven through the furring strips and also

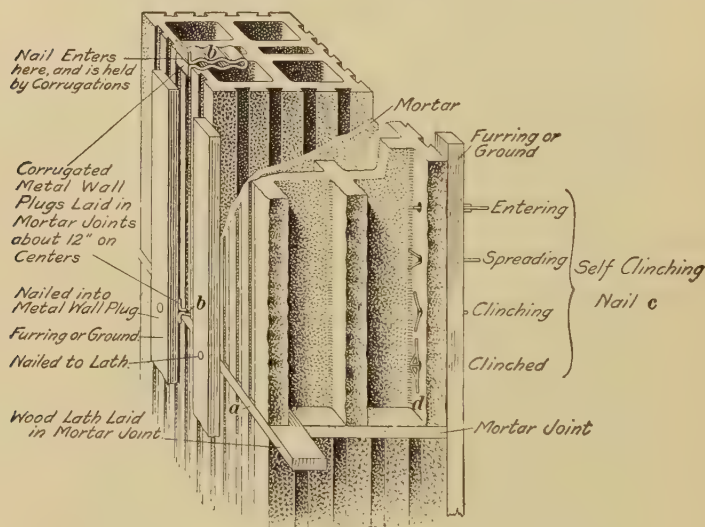


FIG. 47

through the shell of the tile, in which holes have previously been punched. The last blows of the hammer cause the nails to spread and clinch on the back of the shell as shown at *d*. An enlarged view of a self-clinching nail is shown in Fig. 48. In (*a*) the nail is shown closed and ready to drive, in (*b*) the nail is shown driven through the furring and tile and clinched.

91. Toggle-bolts are shown in Fig. 49. These bolts have heads *a* that are hinged to the bolts. A hole is made in the tile of sufficient size to allow the head to enter as shown

in (b). When the head has passed through the hole the head is turned on the hinge so that it stands at right angles to the hole. The threaded shank of the bolt extends through a hole bored through the furring and is fitted with a nut which is screwed up and holds the furring firmly in place. In (c) is a view of a toggle-bolt in position.

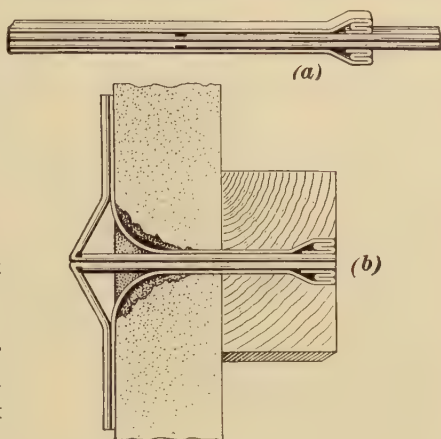


FIG. 48

92. Ankyra Ankor Bolts.—A useful form of expansion bolt for use in securing furring, grounds, etc., to hollow-tile walls is known as the Ankyra Ankor bolt and is illustrated in Fig. 50. In (a) is shown the bolt, which consists

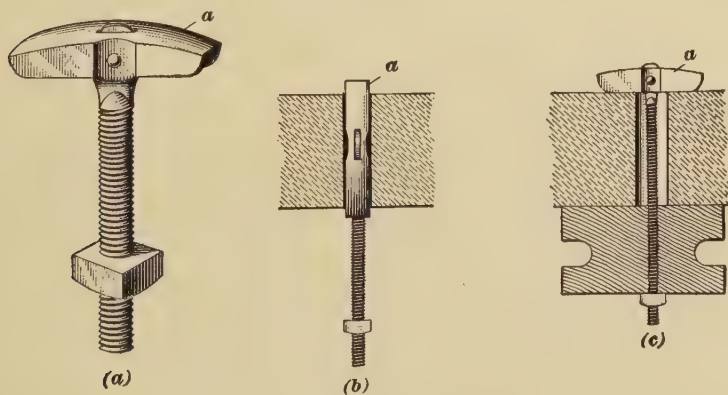


FIG. 49

of a divided shell *a*, a collar *b* with a projecting portion or lug *c*, and a collar *d* which is threaded to receive an ordinary wood screw such as *e e*. In (b) the bolt is shown drawn up so that the shell *a* expands in three directions. In (c) the bolt is

shown under various conditions. At *a* is a hole that is punched through the terra-cotta tile *b* into which the shell of the bolt *c*

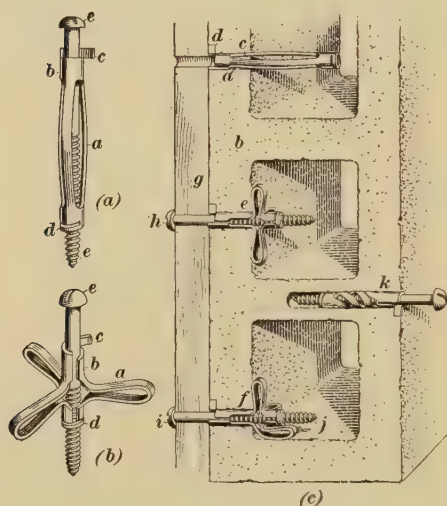


FIG. 50

has been driven. A slight tap of the hammer will drive the lug *d* into the tile and the lug will keep the shell of the bolt from revolving or slipping into the hole. The shell is then pulled together as shown at *e* and *f* by means of a device inserted into it. This establishes the shell firmly in place and it is ready to receive the screw that is to hold the furring in place as shown at

h and *i*. The tighter the screw is turned the firmer the hold this bolt will take. The position that a bolt will take in a corner is shown at *j* and the method of holding in solid terra cotta is illustrated at *k*.

93. Grounds to which trim, base, wainscoting, picture moldings, etc. can be nailed can be secured to the tile walls in the same way as furring strips.

PARTITIONS OF HOLLOW TILE

94. Partitions.—Interior partitions of hollow tile are usually made thinner than outside walls, because they do not have to resist the weather and frequently they carry only light loads. Interior partitions in ordinary houses are built of 3-inch, 4-inch, or 6-inch blocks. In a fireproof house, where the weight of fireproof floors must be taken into account, the main bearing partitions are sometimes made of 8-inch blocks.

It is necessary that tile partitions be rigidly supported. They must therefore rest upon solid walls or partitions beneath or upon steel beams. When fireproof floors are used, partitions in the upper stories may be set on these floors slightly to one side of the partitions below, or, in other words, need not be set directly above them.

The blocks used for partitions are those used in fireproofing and are described in the Section entitled *Fireproofing of Buildings*.

FLOOR SYSTEMS

95. The floor systems used in connection with hollow-tile walls are not peculiar to them. In fact any of the flooring systems used in other buildings can be used equally well in buildings having hollow-tile walls. As these floor systems are described elsewhere, it would be repetition to describe them extensively here, consequently a merely superficial description will be given.

96. Non-fireproof floors, such as are used in ordinary frame structures, are most frequently used in tile buildings, but are not to be recommended, on account of their inflammable nature.

97. Hollow-Tile Fireproof Floors.—While any type of fireproof floor can be used in connection with hollow-tile walls, the most natural fireproof floor to use is one that is composed of the same material as the wall; that is, hollow terra-cotta tile.

Two systems that make use of plain hollow-tile blocks as an essential part of their structure are the *combination floor system* and the *Johnson system*. These types of floors are the ones most used in dwellings. In larger buildings the flat-arch floor systems, the segmental-arch system, and the wire-truss system are employed. As these last-mentioned systems are described in the Section entitled *Fireproofing of Buildings*, they will not be described here.

98. The Combination Floor.—What is generally known as the *combination floor* is frequently employed for

ordinary spans. This floor consists of what may be described as reinforced-concrete beams with hollow tile held between them.

In building such a floor, planks are first erected as a form or temporary support for the entire floor. Upon this form or platform, sometimes called *centering*, the tiles are laid in rows about 16 inches on centers with the cells lying in the direction of the rows. After the tiles are all laid, reinforcing rods are placed at the bottoms of the spaces between the rows and

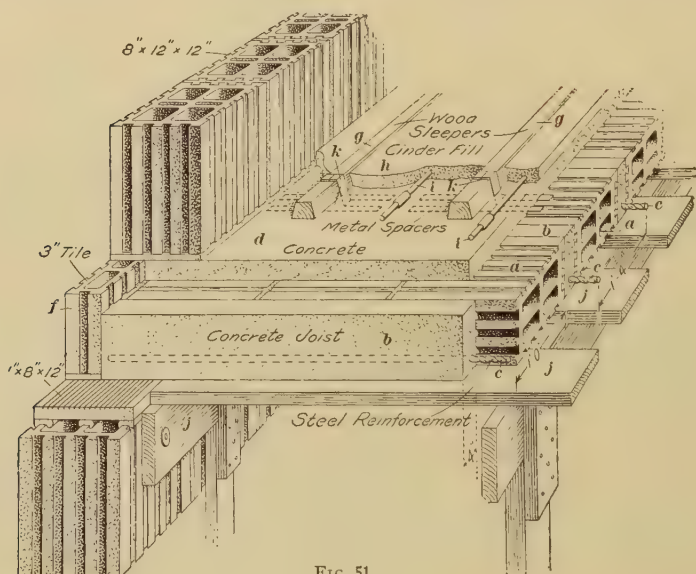


FIG. 51

concrete is poured into the spaces and over the top of the entire construction to a thickness of about 2 inches, as shown in Fig. 51. This figure shows the hollow tile of the floor at *a*, the reinforced beams at *b*, the reinforcing rods at *c*, and the 2-inch layer of concrete over the top of the tile at *d*. The rods *c* are kept up above the centering about $\frac{3}{4}$ inch, so as to be entirely embedded in concrete and thus protected from rusting and fire. The entire construction rests upon 1-inch flat tile slabs set on the wall, and is faced on the outside of the wall

with 3-inch facing tile *f*. The upper wall rests directly upon this floor construction.

On top of the floor construction, wooden cleats, or sleepers, *g* are laid about 12 inches on centers to afford nailing for the wooden floors. These sleepers are made from 2"×4" stuff and are beveled on both sides. They are secured in place by the use of sheet-metal spacers *k*, that are held down by the weight of the concrete that is placed upon them, and are nailed to the sleepers. It is customary to fill in between these sleepers with cinder concrete *h*. After this fill has become thoroughly

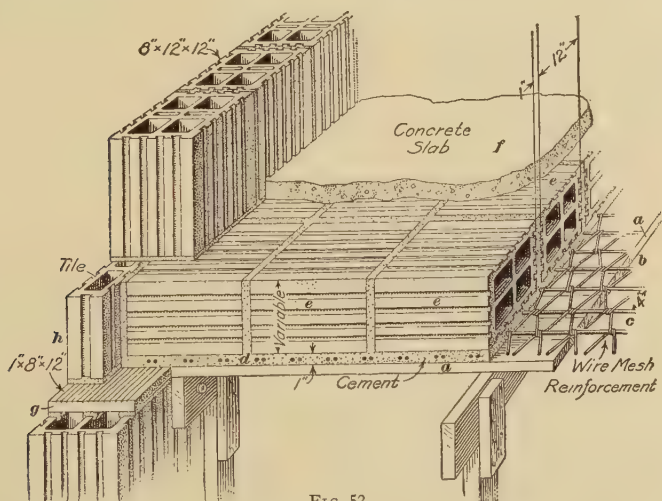


FIG. 52

set, a layer of heavy building paper is placed on top and the finished floor is nailed to the sleepers. Before the cinder concrete is placed between the sleepers, gas and water pipes and electric-wire conduits, as at *i*, are put in place.

The floor is supported on the wooden forms *j* until it has thoroughly set, when the forms may be removed.

99. The Johnson Floor.—Another type of fireproof floor that is frequently used in dwellings and other small buildings is known as the Johnson system, and is formed largely of hollow-tile blocks. The Johnson-system floor is sometimes more economical for wide spans than the combination floor.

In erecting the Johnson floor, a centering *a*, Fig. 52, consisting of a floor made of matched boarding is built, and on this platform a network of steel reinforcement *b* is laid, usually consisting of a heavy metal fabric reinforced by steel reinforcing bars *c*, placed at intervals of 5 or 6 inches. This metal is then embedded in a layer of cement mortar about 1 inch thick. On top of this layer, tile blocks *e* are laid in rows as in combination floors, but about 1 inch apart. The size of the tile varies according to the span and the load.

Concrete is poured into the spaces between the rows of blocks and, where the loads are ordinary, filling these spaces is sufficient. When the loads are heavy a concrete slab *f*,

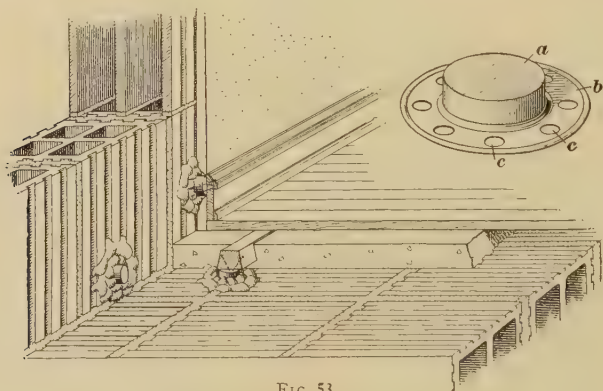


FIG. 53

about 2 inches in thickness, is poured over the tops of the blocks at the same time. As in the case of the combination floor, this floor rests on a flat slab *g* on the wall and is faced on the outside of the wall with a 3-inch facing tile *h*. The details of placing sleepers, pipes, and the finished floors are the same as in the combination floor.

100. Securing Sleepers, or Cleats, to the Floor Construction.—To secure wooden floor sleepers, or cleats, to which the floor is nailed, there are several appliances. One of these consists of small galvanized-iron hooks each of which has a flat end that is embedded in the cinder concrete and a sharp end that is driven into the cleat when the cleat is in its

proper position. These hooks are spaced about 12 inches on centers and hold the cleats firmly in position. Other methods consist of metal strips that are embedded in the cinder concrete and have projecting ends that can be bent over the cleats and nailed to them as shown at *k* in Fig. 51.

A very efficient and ingenious method of attaching furring, sleepers, and grounds to hollow tile is by the use of what are known as *spot grounds*, illustrated in Fig. 53. These grounds consist of a disk of wood *a*, firmly attached to a circular flange of sheet metal *b*, which is perforated with holes *c*. The grounds are secured to the terra-cotta surface by the use of plaster of Paris or Portland cement. Before the plaster has set, the grounds are brought to the correct level so that the furring or sleepers when nailed to the grounds will be straight and level. When the plaster or cement has hardened they afford firm spots into which nails may be driven.

ROOF CONSTRUCTION

101. As has been stated, fireproof roofs are not generally placed on hollow-tile buildings. When, however, they are used they are similar in construction to floors or fireproof roof constructions that are described elsewhere.

STUCCO FINISH

102. Need of Finish on Tile.—The natural appearance of a tile wall is not very attractive or artistic unless the tile is made with special surfaces, as in the case of Textile blocks. Tile walls are, therefore, generally covered with a stucco, or plaster, which is applied so as to produce artistic effects.

COMPOSITION OF STUCCO

103. Stucco.—What is known as *stucco* is in reality a cement plaster formed of Portland cement, sand, lime, and water, and applied in the same manner as ordinary wall plaster.

104. Ingredients of Stucco.—The Portland cement may be of any of the standard brands such as the Atlas, Alpha, Lehigh, Universal, or Vulcanite. These cements are generally of a gray or mouse color and may be used in the first coats of stucco and in the finishing coat when this gray tint is satisfactory.

Portland cement is also made of a pure white color. Such cement is used when it is desired to produce a pure white color in the finishing coat; also when light tints of various colors are required. The white cement merely lightens the tint of any coloring material that may be added to the stucco without destroying the quality of the color. When delicate tints or tones of pink, yellow, or brown are sought, white Portland cement should be used.

105. The **sand** should be clean, free from loam, salt, and other impurities. It should consist of coarse and fine particles mixed together rather than of uniform-sized grains. Ordinary sand possesses a yellowish or reddish color which affects the color of the stucco. When used with a gray Portland cement it results in a gray or mouse-colored stucco. The colors of

the gray cement and the sand greatly modify the effect of mortar colors that are used in coloring stucco and make it impossible to obtain light tints such as buffs, pinks, yellows, etc.

In order to obtain delicate light colors in the stucco, white cement should be used and also *white sand*. Instead of white sand, pulverized marble is sometimes used. This is called *marble dust*. By the use of white cement and white sand or marble dust, light pure tints can be obtained by using small quantities of mortar colors.

With the use of white cement and sand as a base, delicate and desirable tints can be produced by adding **crushed stone** of various colors to the stucco. The stones used for this purpose are marbles, granites, and other crystalline rocks, as well as pebbles that possess high colors. These colored particles of stone should show in the face of the stucco in order to produce a color effect in the wall.

106. The best form of **lime** to use is hydrated lime, which is a carefully and scientifically slaked lime and is in the form of a fine white powder. It can be mixed dry with cement and sand, and when all these ingredients are thoroughly mixed the water can be added.

Lump lime is sometimes used instead of hydrated lime, but must be carefully slaked, strained, and allowed to stand for a week or ten days before using.

107. The **water** used in mixing the stucco should be free from alkalies, acids, and vegetable matter, as these materials may interfere with the setting of the cement.

108. Mortar Colors.—The coloring materials used in tinting stucco are known as *mortar colors*, and are the same as are generally used in coloring mortar used in brick and stone masonry. The best of these mortar colors are sold in pulp form so that they will mix readily with the mortar or stucco. When mixing different batches of colored mortar for the same job, great care should be taken that the same fixed amount of colors is used for a given amount of mortar or stucco. If this is not done the different batches of mortar will show different

tints on the surface of the wall. Only the best and most permanent colors should be used or else the colors will fade or disappear in time.

APPLICATION OF STUCCO

109. The First, or Scratch, Coat.—When the hollow-tile walls of the building have been finished and the roof is in place, the building is ready to be *stuccoed*. As with any plastering, the weather conditions should be suitable; that is, neither too hot nor too cold.

Scaffolds should be erected entirely around the building, after which the mechanics can put on the first coat of stucco,



FIG. 54

which should be pushed firmly against the tile so that it will flow into the grooves and make a secure bond. Deep-grooved tile is best for use in work that is to be stuccoed, as the grooves provide a good mechanical bond between the stucco and the tile. When glazed tile is used, the dovetail scorings on the tile are the only means of holding the plaster to the tile, as the

glazed surface affords no bond whatever. In semiporous tile the slight absorptive power of the surface of the tile affords a grip for the stucco.

When the first coat has hardened slightly it should be *scratched*. This is usually done with a piece of board that has its edge notched, as shown in Fig. 54. This scratching gives a rough surface to which the second coat will adhere. The first coat should thoroughly fill all the grooves in the face of the tile and cover the tile with a thickness of about $\frac{1}{4}$ inch.

110. The Second Coat.—The second coat is applied when the first coat has set but before it has dried. It is when putting on this coat that the surface of the plastering is made true and smooth. This is done by using long straightedges at the corners of the building and around the openings and working the stucco to an even surface between them, all hollow spaces being filled in and projecting ones cut down. All this straightening is done while putting on this second coat.

111. The Third Coat.—After the second coat has set, but before it has dried, the third, or *finishing*, coat is put on. This third coat is the one that is visible to the eye and gives character to the appearance of the building. This character or effect is caused by the color and the texture of the finished surface. By the use of various materials and processes a large variety both of color and texture can be obtained.

FINISHES

112. Color.—As has just been stated, the appearance of the stucco depends upon the manner in which it is finished with regard to color and texture. The matter of obtaining various colors has been considered under the head of the Composition of Stucco. When mortar stains are used, the mass of the stucco is colored uniformly. When, however, the color depends upon the color of the sand or broken stone which is mixed with the stucco, it is generally found necessary to clean away a film of cement which naturally covers these colored aggregates,

so that they may show in the surface of the wall. This is done by scrubbing the wall with brushes and clean water when the stucco is fresh, or by using dilute muriatic acid and brushes if the stucco is several days old. This treatment removes the film of cement and exposes the aggregates in their natural color and brilliancy and the color effect of the wall is determined by the color of these aggregates.

113. Texture.—The texture, or degree of roughness, of the surface of the stucco, has a great effect upon its appearance. A perfectly smooth and even surface can be obtained by using fine materials and working them to a perfectly uniform and smooth surface. It is found, however, that such a treatment is likely to prove flat and uninteresting in its effect. A rough surface is generally more interesting, due to the play of light and shade upon it caused by the projecting particles of mortar.

This texture is obtained by using coarse sand, grit, and pebbles in mixing the stucco, as well as by the method of applying the stucco. The wall surface may be finished smooth by using a steel trowel or it may be made rough by using a cork or wooden float or by placing a piece of carpet over the float. The surface may be roughened by stippling it before it has hardened and a rough but uniform effect obtained. The stucco is often thrown against the second coat and a rough surface produced. The stucco may be mixed with grit or small pebbles and thrown against the second coat and a very rough surface obtained.

Thus it will be seen that there are numerous devices used to obtain what are considered as desirable effects in the finishing coat.

114. Sand Finish.—A *sand-finished* or *sand-floated* surface is obtained by using coarse sand in the final coat. This coat is put on in the usual manner. When it has hardened slightly it is rubbed with a wooden float, using a circular motion which brings the sand to the surface of the stucco and gives a pleasing roughness or texture to the wall.

115. Rough Cast.—When the finishing coat is brought to an even surface, a mixture of cement and sand is thrown against the face of the wall by means of a small wooden paddle or a whisk broom so as to roughen it more or less uniformly.

116. Pebble Dash.—The finishing coat is brought to an even surface and pebbles varying in size from $\frac{1}{4}$ inch to $\frac{1}{2}$ inch are thrown against the soft stucco surface so as to be distributed as evenly as possible. The pebbles should be wet and should be thrown against the surface with sufficient force to make them adhere, or they may be pressed into the stucco with a clean board.

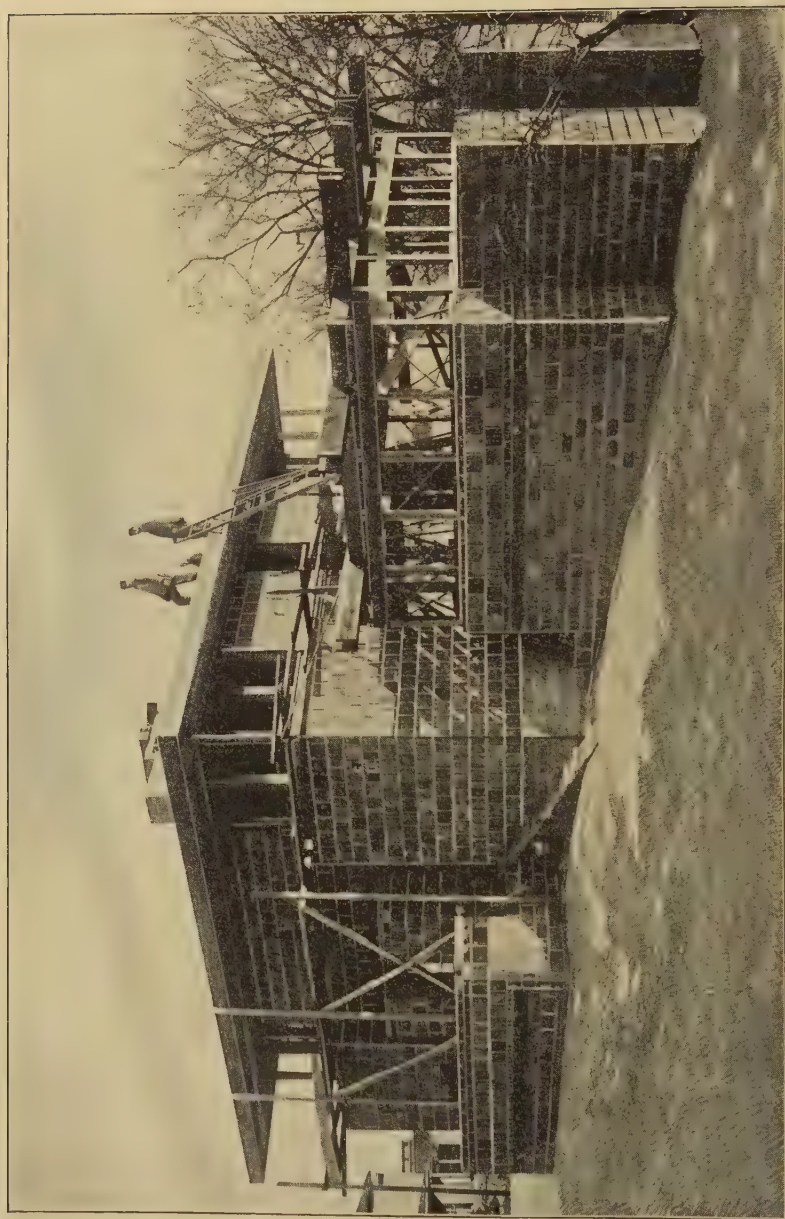
117. Water Necessary.—The stucco should be kept moist at all times until it has been completed. It should be frequently sprayed or should be covered with wet burlap so that it will not dry out too soon.

EXAMPLES OF BUILDINGS OF HOLLOW TILE

118. Dwellings.—Hollow tile is used for dwellings of all kinds, such as bungalows, cottages, and mansions. Illustrations of a dwelling built of Denison load-bearing, or **H**-tile, blocks are given in Figs. 55 and 56. Fig. 55 shows the building ready for plastering and Fig. 56 shows the plaster or stucco coat in place. The stucco surface has been finished in rough cast and presents a coarse and vigorous texture. Figs. 57 and 58 are two dwellings built of **H** tile and ready to receive the stucco coating. These illustrations show quite clearly the methods used in building with hollow-tile blocks.

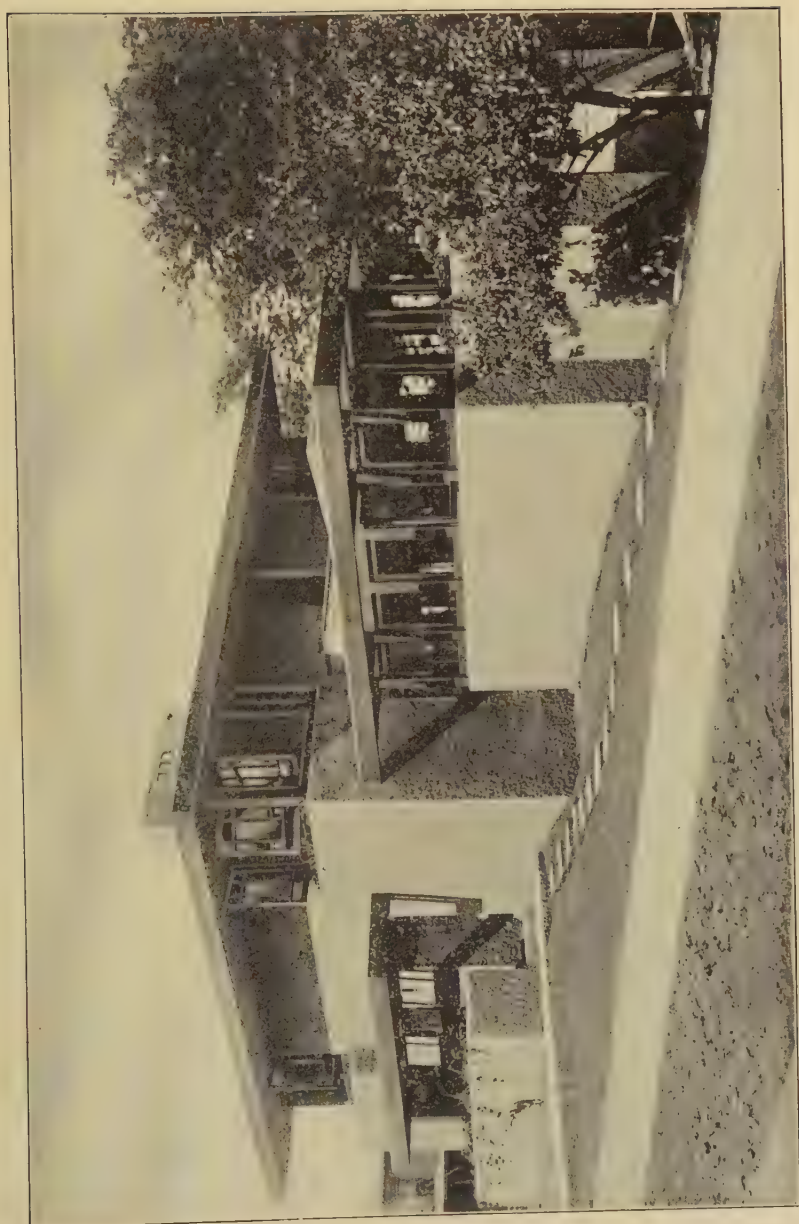
119. Apartment Houses.—Apartment houses are frequently built with walls of hollow tile, such tile being used for outside and inside walls up to the roof; and sometimes fire-proof floors are used.

Examples of apartment houses built of tile are shown in Figs. 59 to 64, inclusive. Fig. 59 shows an apartment building built of interlocking tile, or **T**-shaped tile. This illustration



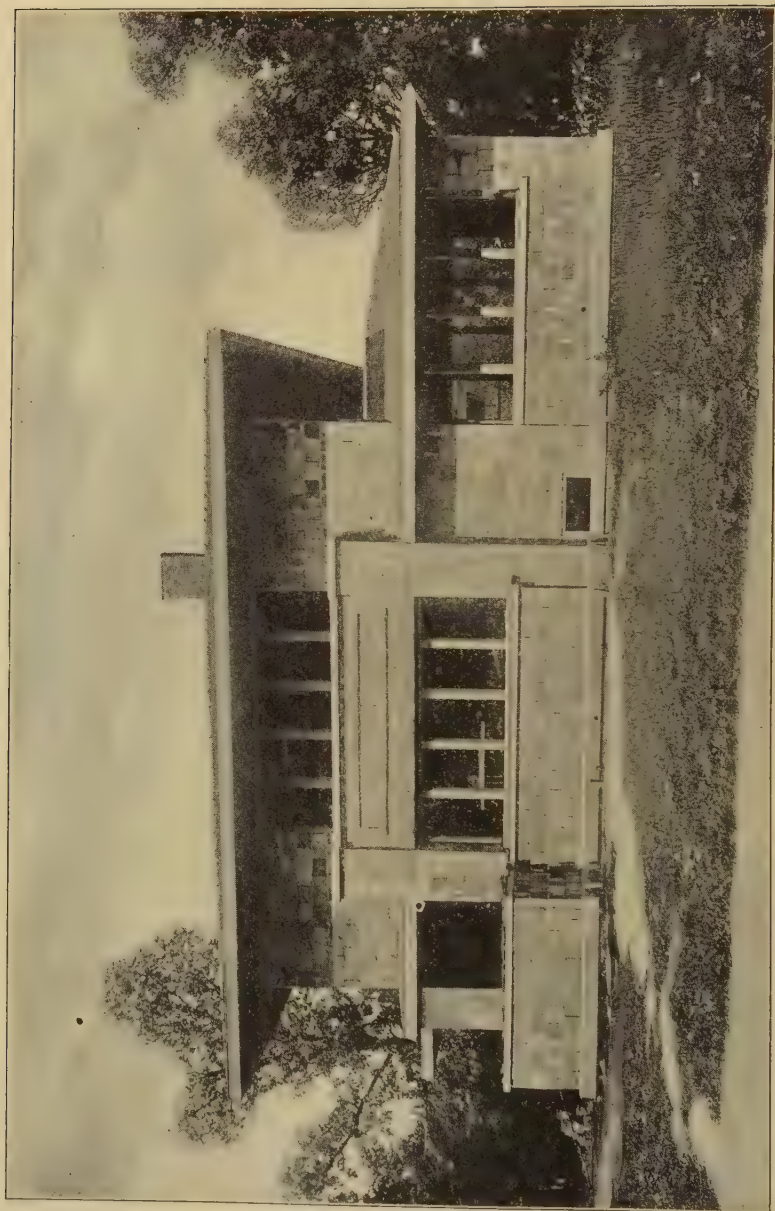
Courtesy of the Denison Fire-Proofing Co., Mason City, Iowa

FIG. 55



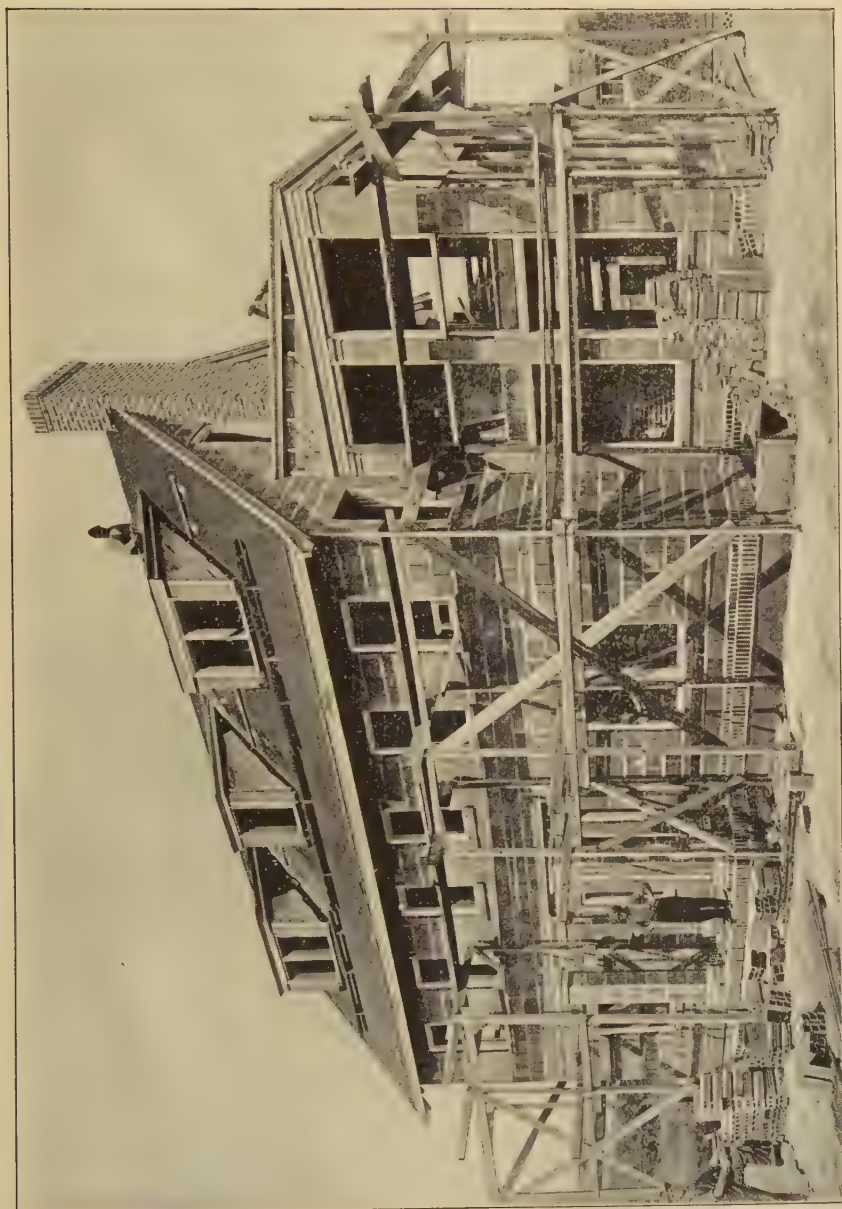
Courtesy of the Denison Fire-Proofing Co., Mason City, Iowa

FIG. 56



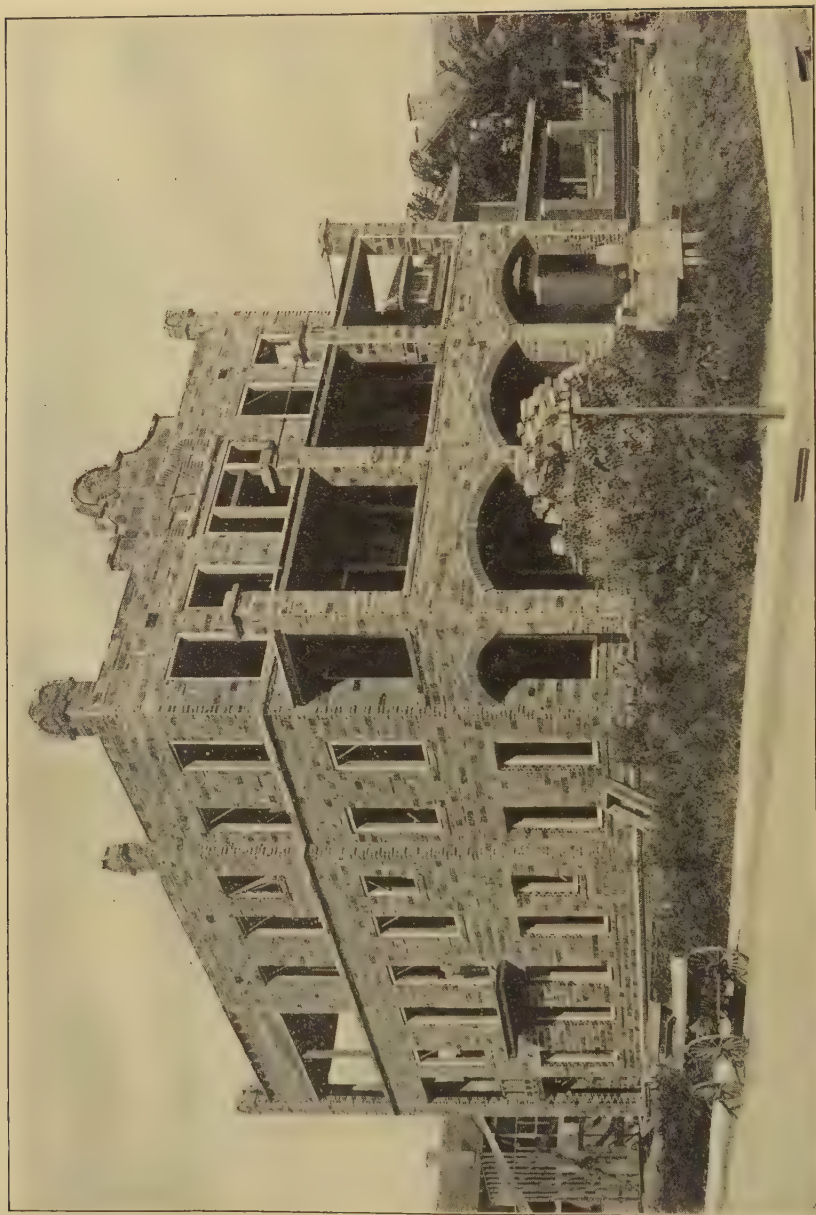
Courtesy of the Denison Fire-Proofing Co., Mason City, Iowa

FIG. 57



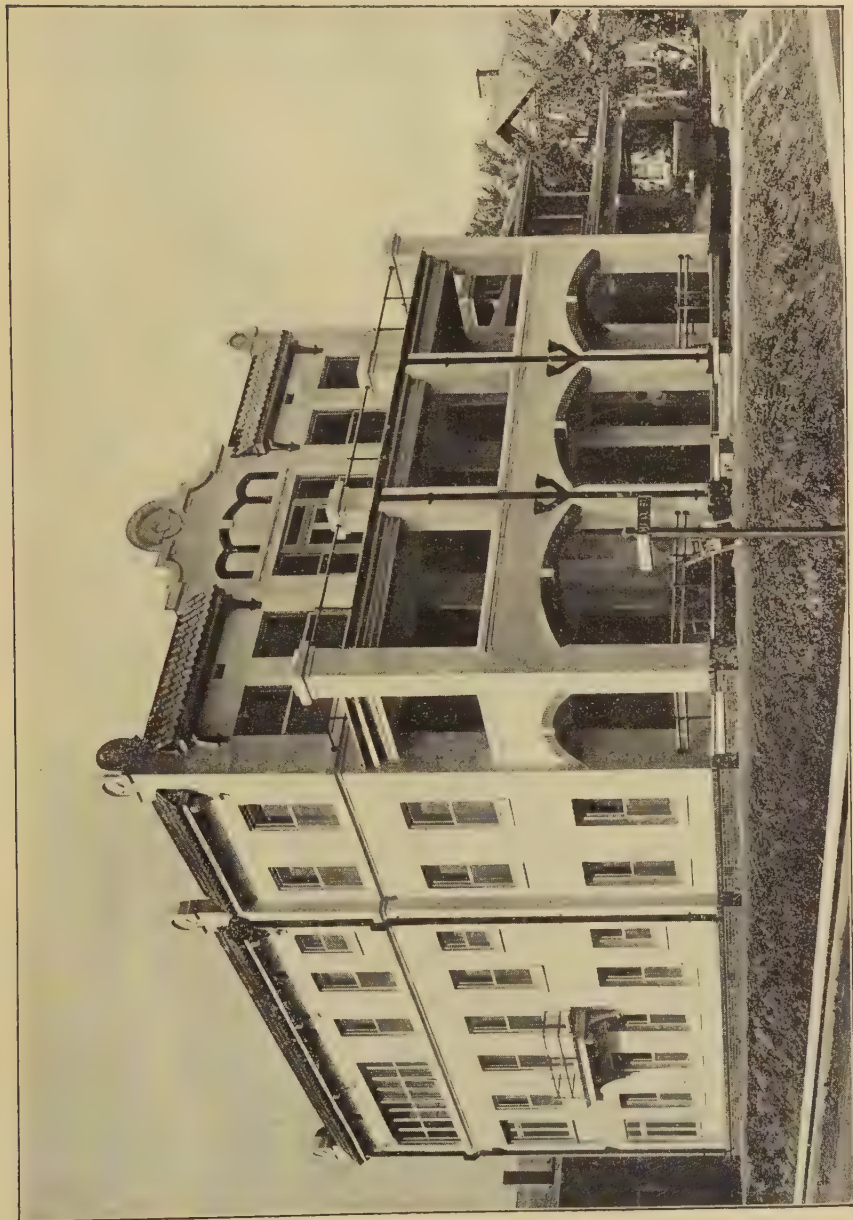
Courtesy of the Demson Fire-Proofing Co., Mason City, Iowa

F. G. 38



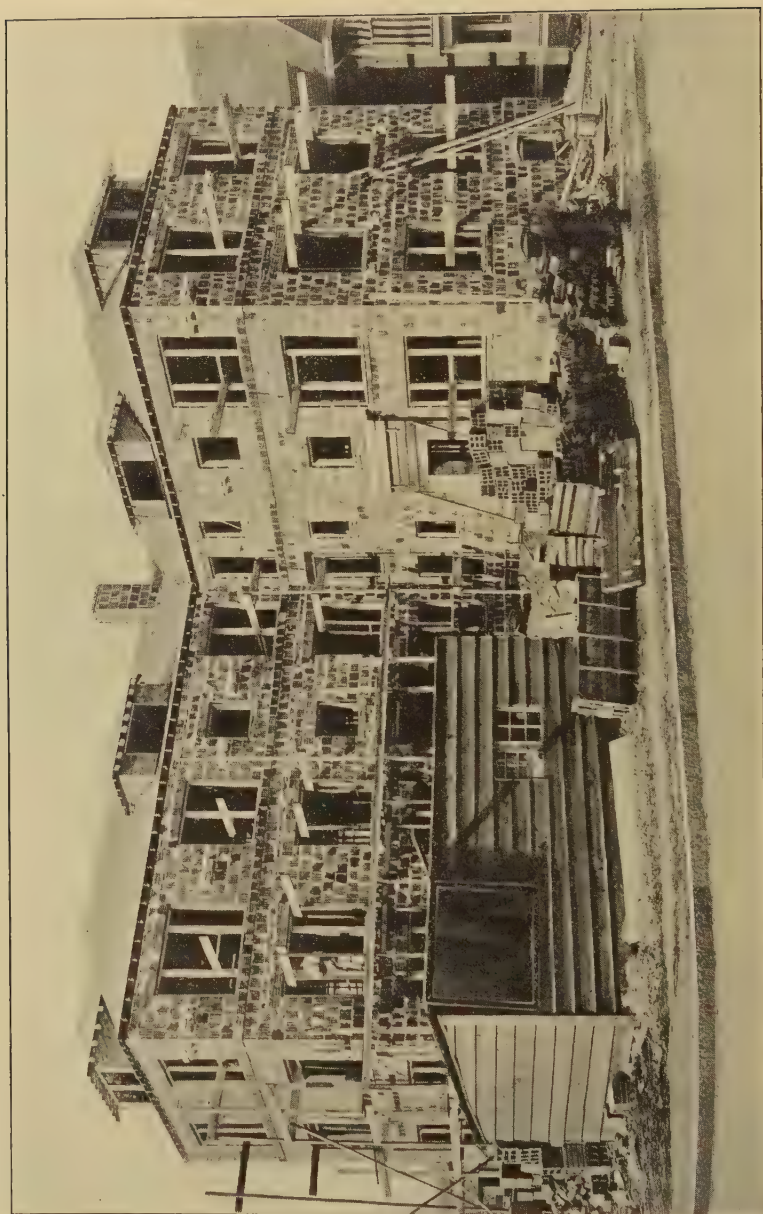
Courtesy of the Denison Interlocking Tile Corporation, Cleveland, Ohio

FIG. 59



Courtesy of the Denison Interlocking Tile Corporation, Cleveland, Ohio

FIG 60



Courtesy of National Fire Proofing Co., Pittsburgh, Pa.

FIG. 52

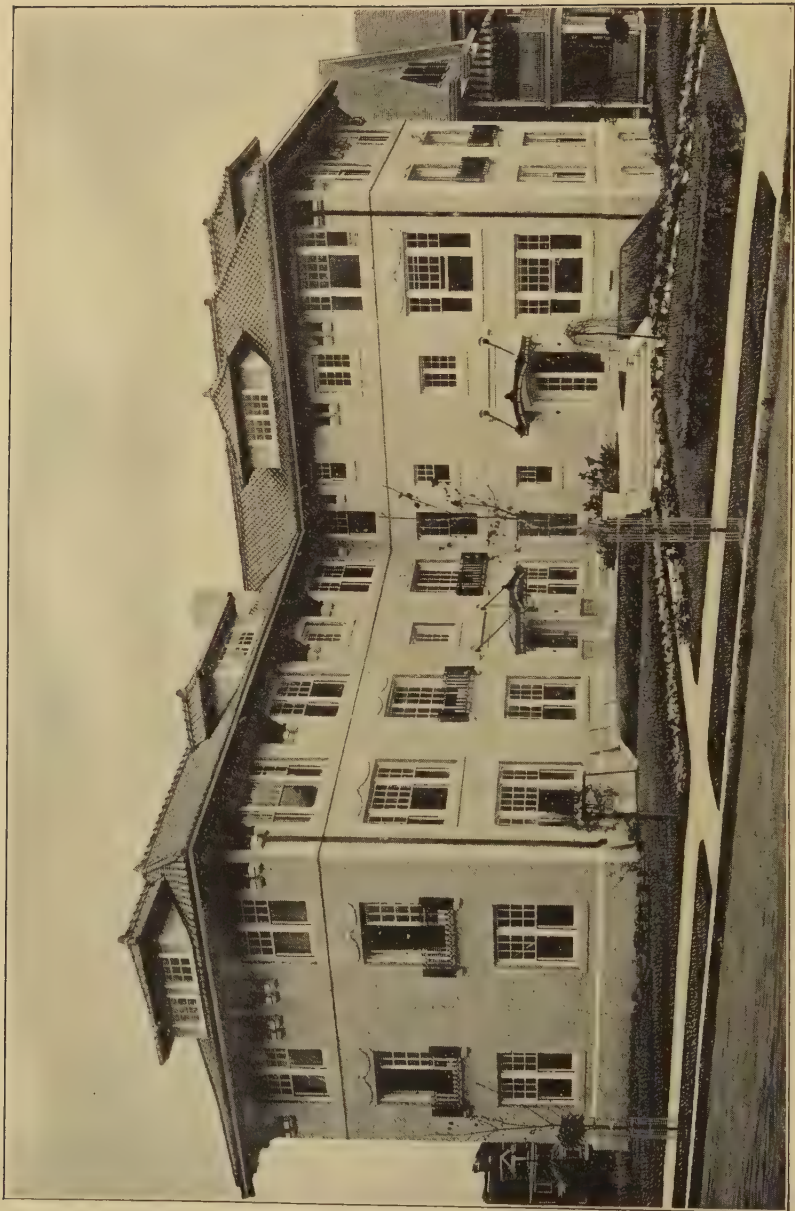
shows the characteristics of hollow-tile construction. The lintels and sills are made of tiles. In some cases corner blocks and jamb blocks have not been used. The cell openings show at the window jambs and corners but will be closed up with cement mortar and will present a satisfactory surface to receive the stucco. Segmental arches are shown on the front porch and are formed of face brick, as shown in the finished building, Fig. 60.

120. Fig. 61 shows an interesting example of hollow-tile construction built of Natco hollow tile. The sills and lintels are of tile as is also the sill course under the third-story windows. The chimney is also built of tile. Corbels of stone to receive the cornice brackets and the balconies are also shown in place. Fig. 62 shows this building finished with stucco rough cast, making a very attractive and interesting structure.

121. A very large apartment house is shown in Figs. 63 and 64. Fig. 63 shows the exterior walls built of Natco, or standard-shaped, tile. In this case the doorways, string-courses, and the trim of some of the windows are of stone and are built into the terra-cotta wall. The wall is shown with its stucco coating in Fig. 64. It will be noticed that the stucco in the first story has been treated to represent stone having rusticated joints. Quoins have been formed of stucco in the upper stories at the corners. The effect of this building is dignified and substantial.

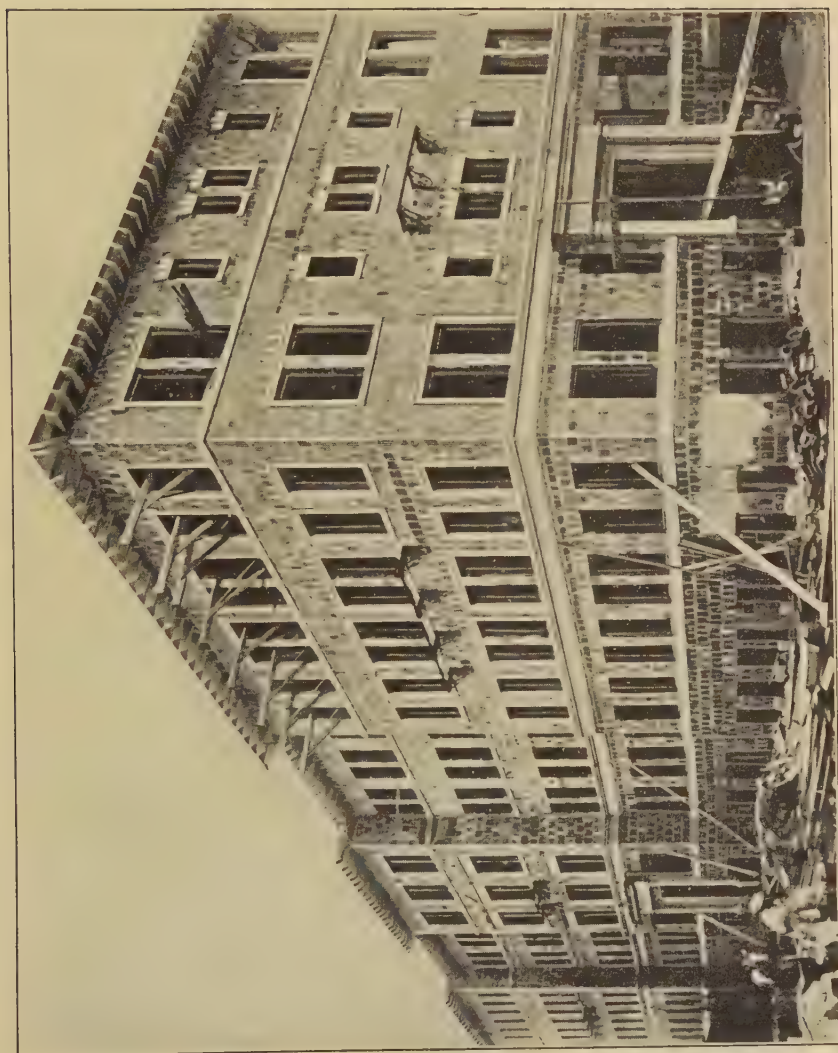
122. Factories and Warehouses.—In factories where very heavy loads do not occur, the same form of construction can be employed as for apartments and dwellings. Instead of interior tile partitions, however, steel columns and girders may be used. The outside walls can be made of hollow tile stuccoed, left with a smooth finish of the block showing, or veneered with brick.

Many of the latest types of factories and warehouses are built with a framework of reinforced concrete, consisting of posts, girders, and slab floors. After this framework is completed the spaces between the posts and girders on the outside walls are filled in with hollow tile as shown in Fig. 65. In this



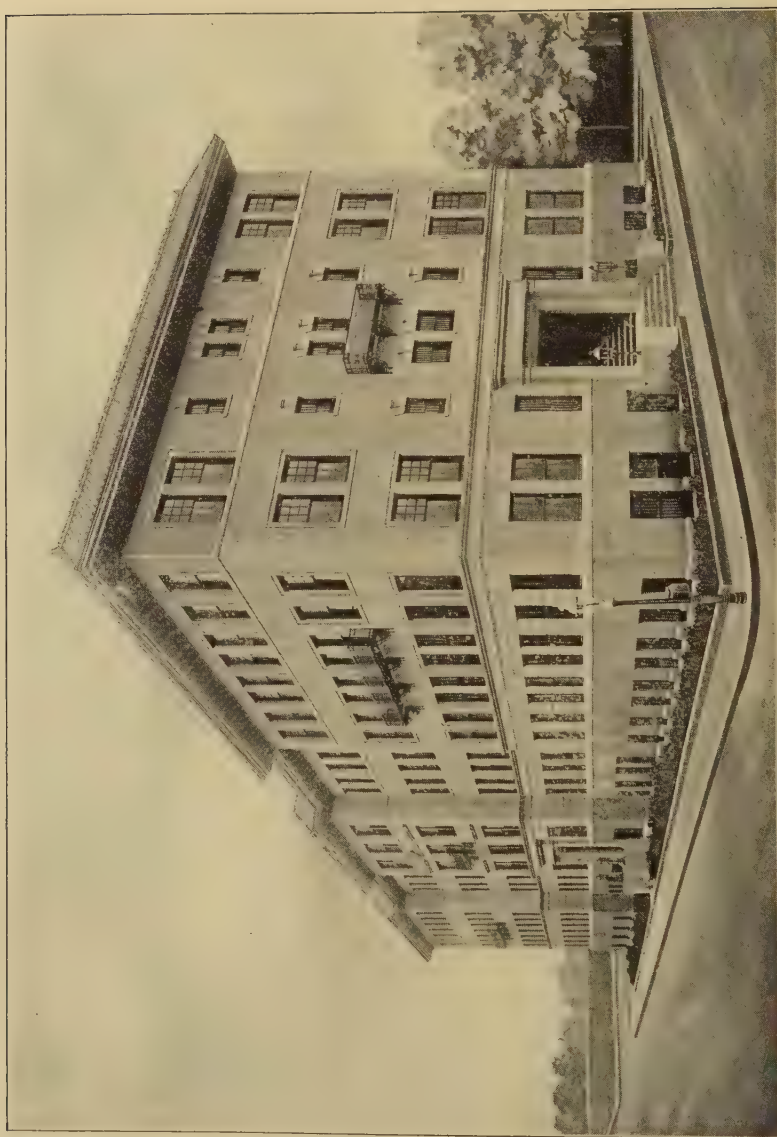
Courtesy of National Fire Proofing Co., Pittsburgh, Pa.

FIG. 62



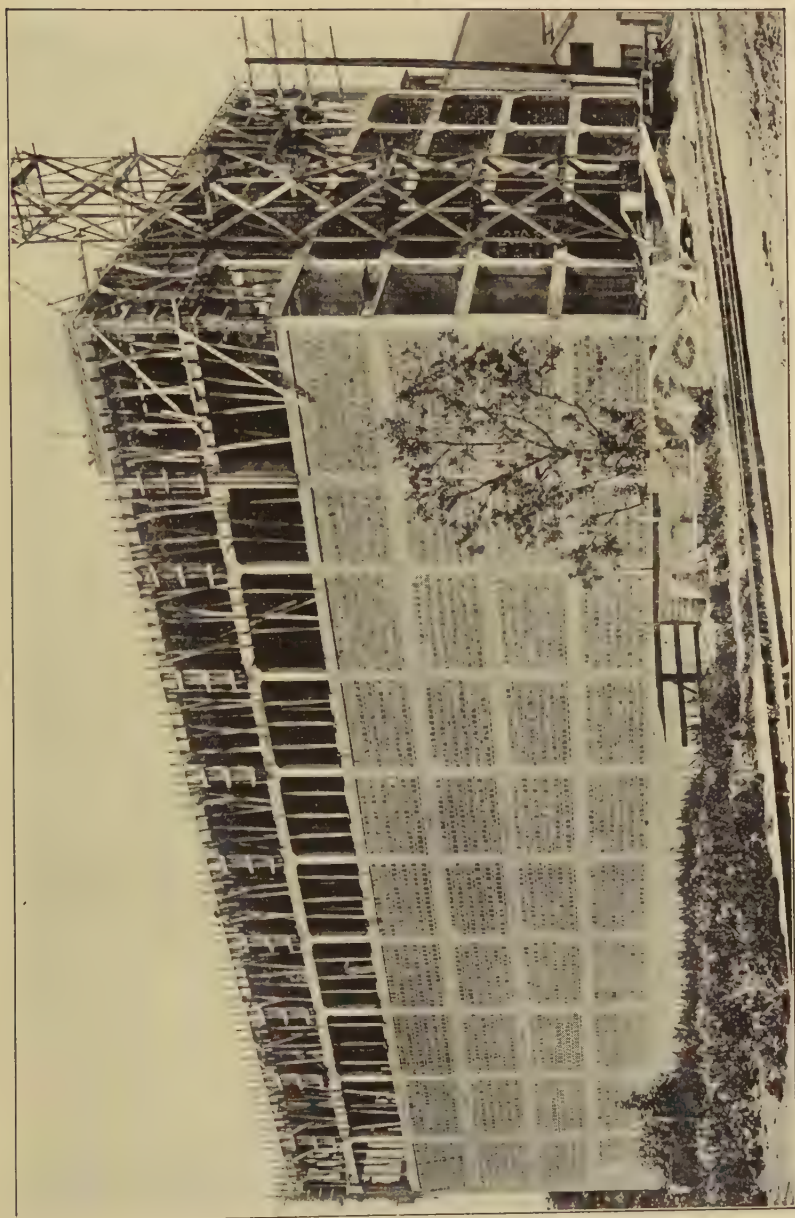
Courtesy of National Fire Proofing Co., Pittsburgh, Pa.

FIG. 63

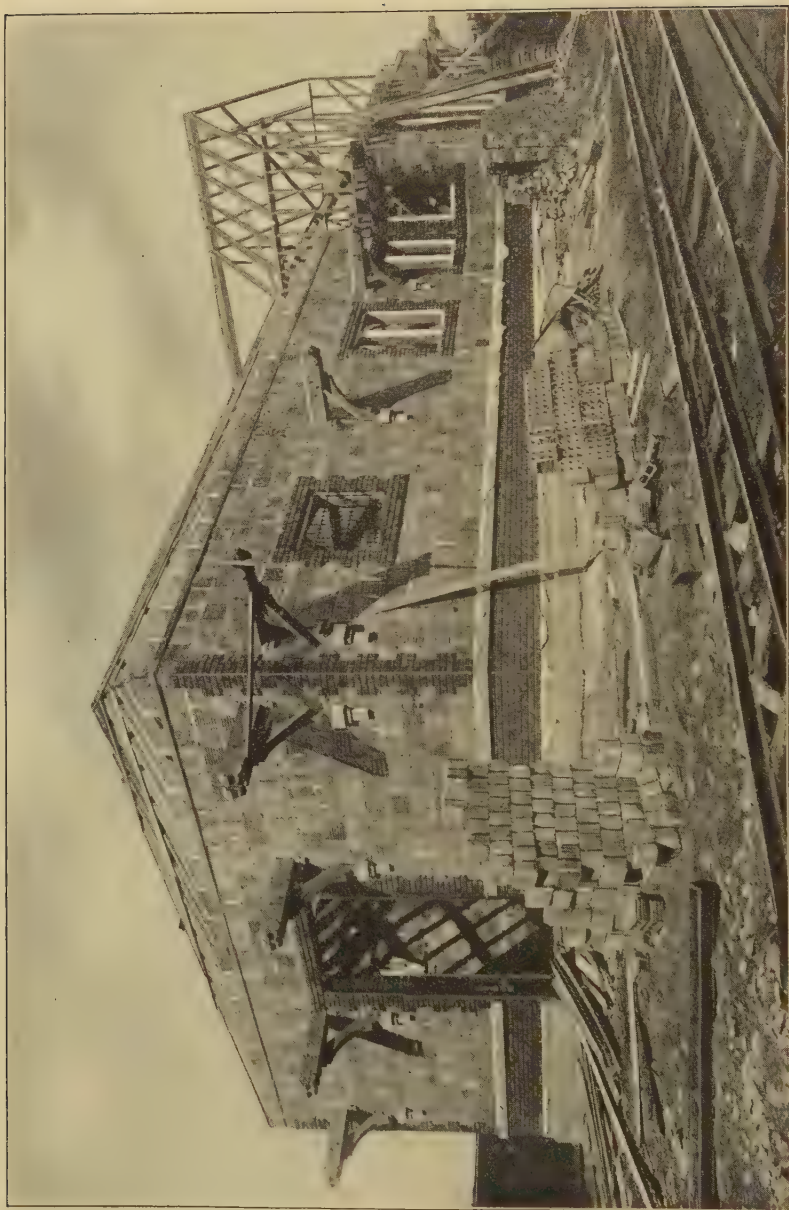


Courtesy of National Fire Proofing Co., Pittsburgh, Pa.

FIG. 64

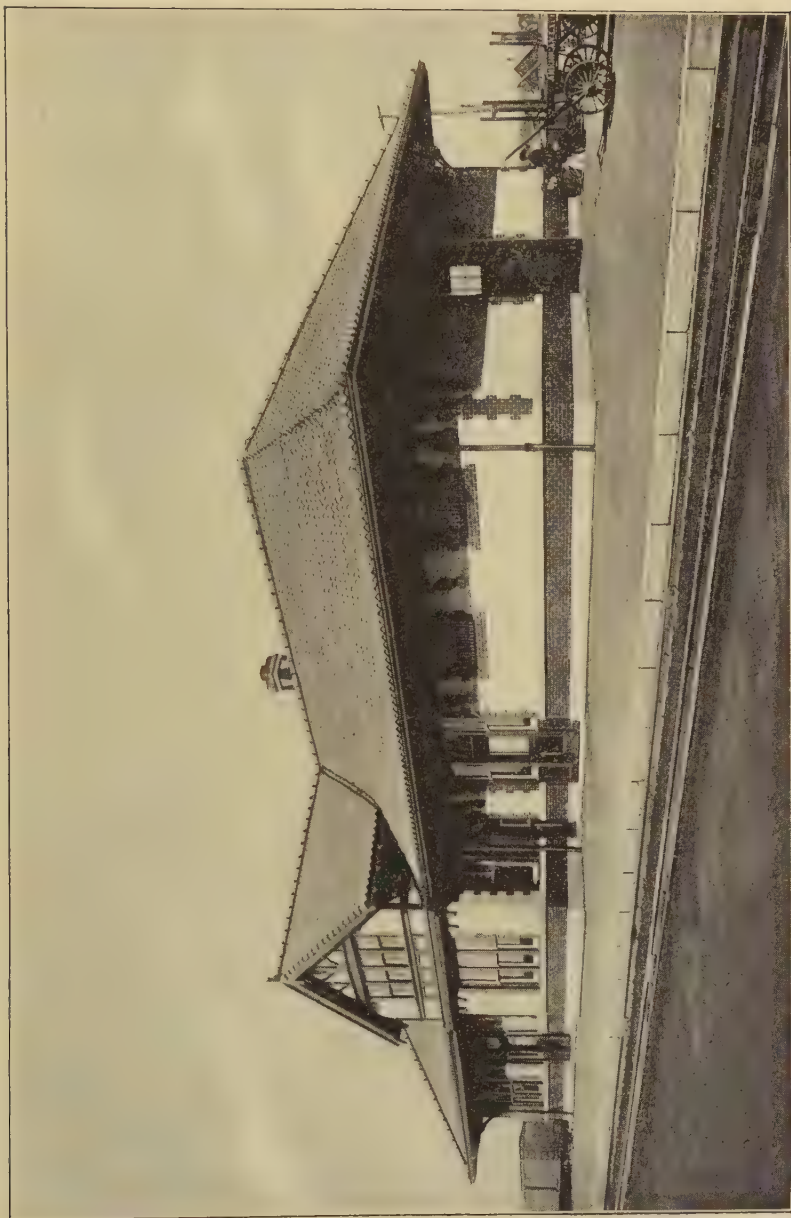


Courtesy of the Denison Interlocking Tile Corporation, Cleveland, Ohio
FIG. 65



Courtesy of the Denison Fire-Proofing Co., Mason City, Iowa

FIG. 66



Courtesy of the Denison Fire-Proofing Co., Mason City, Iowa

FIG. 67

case **T**-shaped, or Denison Interlocking, tile has been used. This filling-in is much lighter than brickwork and consequently does not require such heavy posts and girders to support it.

123. Office Buildings.—In tall office buildings, the framework is usually of steel, although in smaller buildings a reinforced framework is sometimes used. A considerable saving in weight and in the size and cost of the frame can be made by using hollow terra-cotta tile for filling in the walls between the columns and girders. These walls can, if desired, be veneered, or faced, with 4 inches of brickwork.

124. Railroad Stations.—An example of a railroad station built of Denison **H** tile is shown in Figs. 66 and 67. In Fig. 66 a stone base course and string-course are shown with a band of face brick between them. Above this is a hollow-tile wall. The windows are trimmed with face brick. The corners have a finish of face brick. Stone brackets and wooden brackets are built into the walls and the wall is ready for plastering. The finished building is shown in Fig. 67 and illustrates the possibilities of the use of hollow tile.

BUILDING STONE

VARIETIES AND QUALITIES OF STONE

INTRODUCTION

1. In order to be able to decide which kind of stone is best to use under given conditions, a knowledge of the different kinds employed in building construction is very essential. It is not necessary for a builder to determine the exact composition of a stone, but his knowledge should be sufficient to aid him in selecting or specifying the kind of stone best adapted to the purposes for which it is intended. In this Section will be described some of the principal building stones of this country, classed according to composition and structure.

GRANITES

2. **Granites** are never found in layers, or strata; they consist of an aggregation of feldspar, quartz, and mica crystals, the principal impurities being hornblende and talc. The usual colors are white, gray, yellow, and shades of red, while the quality varies with the proportions of the component parts, the hardest stone containing more quartz and less feldspar and mica than the softer varieties. Hornblende renders the stone tough and heavy, feldspar makes it easier to cut and more susceptible to decomposition, while mica renders it friable.

3. Granite may be quarried easily, as it cleaves with regularity, and can usually be obtained in any size desired.

Owing to its hardness and toughness, however, great difficulty is experienced in working this stone, these qualities making it very expensive to cut and thus preventing its use in fine carving. Nevertheless, it is susceptible of a high polish, which makes a durable finish.

Granite is probably the best stone for foundations, and is extensively used in other positions requiring great strength; it is also put to such minor uses as flagging, thresholds, and water-tables. All kinds of granite are damaged considerably by the action of fire, which causes them to crack badly. They disintegrate at temperatures ranging from 900° to 1,000° F. The average weight of granite is about 166 pounds per cubic foot.

Granite is found in the eastern and western parts of the United States and in Canada, the gray variety occurring principally in the New England States and Virginia, while the red variety, which is usually harder, is found near the Bay of Fundy, on the islands of the St. Lawrence River, in Virginia, near Lake Superior, in Maine, and in many parts of the Rocky Mountains.

4. Gneiss.—Gneiss, which is also a crystallized rock, is constituted similarly to granite, but is distinguished from it by being arranged somewhat in parallel layers. Owing to this peculiarity, the rock splits into slabs having approximately parallel surfaces, thus making it valuable for walls, street paving, etc. Gneiss is called *stratified*, or *bastard*, *granite* by quarrymen.

5. Syenite.—The stone known as **syenite** consists of orthoclase and hornblende, which are frequently associated with mica and quartz. It has a granular texture resembling granite, is hard, tough, and somewhat coarse-grained, but will not take a polish.

6. Trap.—Trap is a rock consisting of hornblende and feldspar. It breaks into blocks with ease, but has no apparent granular structure. Owing to the difficulty of quarrying this rock in large pieces, it is seldom used as a building stone, although it makes an excellent aggregate for concrete.

LIMESTONES

7. The limestones used in building construction consist of lime in combination with one or more of the following constituents: silica, clay, talc, hornblende, mica, carbonate of magnesia, and iron. Fossil remains, such as shells, coral, etc., usually in a more or less pulverized condition, are frequently found in them. The term limestone is very general, and includes many varieties that differ entirely from one another in structure. Not all of these are suitable for building purposes, however, and care and experience are required to make the proper selection.

The principal limestones used for building purposes are the common, the fine-grained crystalline (usually called *marbles*), and the magnesian varieties. Limestones containing 10 per cent. or more of magnesia are called *magnesian*, and those having over 45 per cent. of that substance are termed *dolomites*. Dolomites are crystalline and granular in structure, and usually have a white or yellowish tinge.

In color, limestones are generally light gray, blue, or buff. Good examples are those obtained from Bedford, Indiana, and Bowling Green, Kentucky; both of these limestones are very durable, and may be classed among the best building stones. Limestones, although durable, are easily stained by the smoke in large cities. They are quite heavy, weighing about 150 pounds per cubic foot, and will take a high polish. They are also easy to work, but are easily destroyed by fire.

8. **Marble** is a crystallized limestone, and one of the most valuable building materials. It can be obtained in many colors—white, gray, red, blue, green, and black—and most of its varieties will take a high polish. One of the most important characteristics of marble is that it is easy to carve; the finer the grains of the stone, the more suitable it is for this purpose. The fine white-grained varieties that are especially prized for sculpture are called *saccharoid marble*.

Marble is a valuable material for exterior construction, as it resists frost and moisture well, but like all limestones it will not withstand fire.

Some of the finest varieties of white American marble are found at Lee, Massachusetts, and in the vicinity of Rutland, Vermont. The dark-blue marble from the Vermont quarries is very durable and has a very close grain. A fine black marble is quarried at Glens Falls, New York. Colored marbles, including gray, light and dark pink, buff, chocolate, etc., are found in Tennessee, Georgia, and many other places.

9. Onyx Marble.—The term **onyx** is applied to some kinds of marbles for the reason that their banded appearance somewhat resembles that of true onyx. These marbles have the same general composition as the common varieties of marble, but are formed in a purely chemical manner instead of in ordinary sedimentary beds. Their variegated colors are due to the presence of metallic oxides and other impurities.

Onyx can be worked and polished very readily, and is considered the handsomest of building stones, owing to its translucence and great variety of colors. It is used almost entirely for interior decoration, in wainscoting, mantels, etc. The stone presents the best appearance when cut across the grain, but this impairs the strength and necessitates a backing of stronger marble. Most of the onyx used in this country comes from Mexico and California.

SANDSTONES

10. Sandstones are so called because they are formed by the cementation of particles of sand—usually quartz grains—into rock. The character of the stone depends greatly on the nature of the cementing material. If the grains have been cemented by fusion, or under great pressure, the stone is nearly as hard as quartz; this variety is known as *quartzite*, and is very strong and durable.

When the cementing material is silica, the stone usually has a light-gray color and is hard to cut; but if the grains are cemented by oxide of iron, the stone is either red or brown

and is much softer. With carbonate of lime as a cement, the result is a light-colored or gray stone, soft and easy to work, but does not, as a rule, weather well. Sandstone containing clay is the poorest, as it easily absorbs water, which, on freezing, rapidly disintegrates the stone.

Sandstones include some of the finest and most durable stones for outside construction. The ease of working them and their wide distribution cause them to be very extensively used. The stone is found in a great variety of colors—shades of gray, brown, buff, pink, red, drab, and blue being common—which depend largely on the quantity of iron oxides contained in the stone. The presence of these is not injurious, but no sandstone containing iron pyrites should be used for exterior work, as it is almost sure to become stained by rust.

Sandstones vary in texture from those in which the grains are almost imperceptible to those having grains like coarse sand; the finer the grain, the more easily can the stone be carved. Quarried sandstones usually hold considerable water, which renders them soft and easy to work; but nearly all become harder as the water evaporates, and the stone should not be subjected to heavy loads until the water is dried out.

11. Blue shale, or bluestone, is a variety of argillaceous, or clayey, sandstone having a bluish color. It is very hard and dense and makes an excellent material for foundations, flagging, etc. Bluestone is found in large quantities along the Hudson River, in the vicinity of Kingston, New York.

QUALITIES OF GOOD STONE

12. No branch of masonwork, from an architectural standpoint, is of greater importance than the selection of stone for structural purposes; and the qualities of stone, such as its strength and durability when exposed to variations of temperature and action of the weather, its permanence of color, etc., are points that should be studied with care.

13. Strength.—Whenever a stone is to be used for foundations, piers, lintels, bearing blocks, etc., its strength is a matter of importance. If the stone appears to be first class, its strength may be assumed as equal to the average strength of stones of that kind, as determined by experiment.

The cap and bond stones for piers carrying iron columns and the bearing blocks under the ends of the girders should be either granite, bluestone, or hard, blue, Vermont marble. For use in such situations, the safe bearing strength should not be assumed greater than one-tenth of the crushing strength. The stones in piers for warehouses and office buildings are often subjected to loads of from 60,000 to 70,000 pounds per square foot.

14. In Table I is given the load per square inch at which the different kinds of stone fail.

15. Weight of Stone.—The following are average weights per cubic foot of stone of the classes mentioned:

Marble, in blocks	170 pounds
Limestone, in blocks	150 pounds
Granite, in blocks	166 pounds
Sandstone, in blocks	139 pounds
Slate, in blocks	174 pounds

The New York, Boston, and Chicago building laws give the weight of building stones of all kinds, when laid in the wall, at 165 pounds per cubic foot, which is near enough for most computations.

16. Color.—In rural districts and places where little or no soft coal is consumed, light-colored stones may be used without any danger of becoming dirty or disfigured, while in very smoky cities they will get very dark in a few years. In such cases, the red or brown silicious, or flinty, sandstones are the most desirable; and next in value are the granites. The stone that retains its native color best is the most desirable to use; but, in localities where all classes of stone change, the one to be preferred is that in which the alteration is the least, and uniform throughout.

TABLE I
CRUSHING STRENGTH OF STONE

Granites—		Kinds of Stone	Strength Pounds per Square Inch
Staten Island, blue	22,250		
Maine	15,000		
Quincy, Massachusetts	17,750		
Richmond, Virginia	21,250		
Cape Ann, Massachusetts	{ 12,420 19,500		
Westerly, Rhode Island	14,940		
Fall River, Massachusetts	15,940		
Duluth, Minnesota	17,750		
Maryland	19,430		
<i>Limestones—</i>			
Glens Falls, New York	11,475		
Lake Champlain, New York	25,000		
Kingston, New York	20,700		
Joliet, Illinois	16,900		
Lime Island, Michigan	{ 23,000 18,000		
Bardstown, Kentucky	16,250		
Cooper County, Missouri	6,950		
North River bluestone	19,820		
<i>Marbles—</i>			
East Chester, New York	13,500		
Italian, common	13,000		

		Kinds of Stone	Strength Pounds per Square Inch
<i>Marbles—</i>			
Dorset, Vermont	7,61		
Proctor, Vermont, blue	14,410		
Lee, Massachusetts, white	13,440		
Mill Creek, Illinois, drab	9,700		
North Bay, Wisconsin, drab	20,000		
<i>Sandstones—</i>			
Little Falls, New York, brown	9,850		
Belleville, New Jersey, gray and red	11,700		
Middletown, Connecticut, brown	6,950		
Haverstraw, New York, red	4,350		
Medina, New York, pink	17,700		
Berea, Ohio, drab	{ 7,250 10,250		
Vermilion, Ohio, drab	8,850		
Marquette, Michigan, gray	7,450		
Seneca, Ohio, reddish brown	9,700		
Cleveland, Ohio, olive green	6,800		
Albion, New York, brown	13,500		
Kasota, Minnesota, pink	10,700		
Frontenac, Minnesota, light buff	6,250		
Dorchester, New Brunswick, freestone	9,150		
Massillon, Ohio, yellowish drab	8,750		
Warrensburg, Missouri, bluish drab	5,000		

17. Durability.—The durability of stonework is of prime importance, as on this property depends the life of a structure. It is evident, therefore, that buildings of importance should be constructed of the most durable stone that can be economically obtained in the locality in which the building is to be erected.

Table II, taken from a United States census, gives the length of time that the several varieties of stone named have lasted in New York City without material deterioration:

TABLE II
DURABILITY OF BUILDING STONE

Variety of Stone	Years
Brownstone, coarse	5 to 15
Brownstone, fine laminated	20 to 50
Brownstone, compact	100 to 200
Bluestone (blue shale)	100 to 200
Sandstone, Nova Scotia	50 to 100
Limestone, Ohio, best silicious	100 to 200
Limestone, coarse fossiliferous	20 to 40
Limestone, oolitic	30 to 40
Marble, coarse dolomite	40 to 50
Marble, fine dolomite	50 to 100
Granite	75 to 200
Gneiss	50 to 200

18. Probably ordinary variations of temperature test building stones most severely. Stones consist of particles cohering more or less closely, and an increase in temperature causes each particle to expand, tending to force apart those surrounding it, while with a lowering of temperature a corresponding contraction occurs. As the temperature is ever varying, there is a continual motion of the particles, which, although very small, will in course of time produce cracks and result in the slow and gradual destruction of the stone. Such changes are among the most potent causes of the disintegration of stone.

The effect of frost on stones saturated with moisture is always disastrous. The expansive force exerted by water in solidifying is nearly 140 tons per square foot; hence, a stone of open texture exposed to heavy rains and then to the action of frost must suffer deterioration in course of time. Sandstones are the most porous, and granites the least; for this reason, granite is best adapted for use in wet places, as in foundations.

19. When atmospheric gases are brought in contact with the exposed surfaces of some kinds of stone by rains, the durability of the stones is often affected. The changes are the results of oxidation and solution. When iron exists in stone in the form of pyrites, it becomes combined with the oxygen in the air and produces the discoloration known as *rust*. When very minute, these particles of iron pyrites are not injurious, and the only effect of the rust is to give the stone a yellowish tinge; but if the pieces are of considerable size, the oxidation will discolor the stone unevenly. Some authorities claim that the presence of pyrites in small quantities is beneficial to the stone, as it increases the tenacity by its cementing qualities.

20. Pure water has practically no effect on building stone. Rain, however, contains traces of nitric, sulphuric, and other acids, absorbed from the smoke and other impurities in the air, and when these are brought in contact with stones, they tend to dissolve all portions that are soluble. Lime and magnesia in the form of carbonates (as in all marbles and limestones) are, in particular, easily acted on; sandstones containing iron or lime suffer from the same causes, while granites are the least affected.

21. Heavy pounding or hammering has a tendency to destroy the cohesion of the grains and thus renders the stone more susceptible to climatic influences. Only granites and the hardest sandstones should be peen- or bush-hammered. The most durable surface for granite is *rock-faced*, as the crystalline facets, being but little disturbed in

the dressing, shed moisture readily. For other stones, however, a smooth surface is usually the best in a changeable climate. Quarrying by explosives often causes cracks in the stone that are so small as to be unseen until the application of the load increases them enough to make them visible. The fracture of stones in buildings is often due more to imperfect setting than to any lack of strength in the stone.

For some purposes, as for steps, door sills, paving, etc., the *hardness* of a stone is of importance, in which case granites and other hard stones are the most suitable.

22. Stone should always be laid on its natural bed wherever possible. If placed so that the layers, as found in the quarry, are vertical, water penetrates between them much more easily, and, in freezing, will very quickly split the stone. Stones, such as sill and belt courses, so placed that rain washes over them, will deteriorate much more rapidly than the rest of the masonry, and on this account should always be the most durable kinds.

In selecting building stone, it is often important to obtain a kind that possesses good fire-resisting properties. The fine-grained, compact sandstones endure fire the best; while the exposed surfaces of limestones and marbles become converted into lime by intense heat. Granites are more affected than sandstones, but less than limestones.

23. Seasoning Stone.—In order to evaporate the quarry water that most limestones and sandstones contain when freshly quarried, they should be exposed to the air for a considerable time before being used; this seasoning makes the stone harder and also more durable under the action of frost. It is supposed that the quarry water contains in solution considerable cementing material and that this is deposited when the water evaporates, firmly binding together the particles. It can readily be seen that all necessary cutting or carving on stone of this kind should be done as soon as possible after quarrying.

INSPECTION AND TESTS

24. A close inspection should be made of all stone before it is used, to see that the specified quality is being delivered. When large quantities of stone are to be used, it is even advisable to visit the quarry in order to make any necessary tests. The tests usually made to assist in determining the qualities of stone, as to durability, etc., are for *compactness* and *hardness*, *absorption* and *solubility*.

25. Compactness.—The densest and strongest stones are generally the most durable. An idea of the compactness may be obtained by examining, through a good magnifying glass, the surfaces of freshly fractured stone, which should be clear and bright, with the particles well cemented. A dull earthy-looking fracture indicates liability to quick deterioration, while if the stone gives forth a clear metallic sound when struck with a hammer, it is a good indication of its compactness.

26. Absorption.—The tendency of a stone to absorb water should be considered with regard to the effect on the appearance of the building. While a dense non-absorbent stone is restored to its original color by a heavy rain, one of open texture will quickly absorb the water, which carries dust and soot into the pores of the stone and thus makes it very dirty in a short time.

Generally, the most durable stones are those that absorb the least water. In order to test the absorptive qualities of a stone, a good average specimen should be thoroughly dried, carefully weighed, and immersed in water for 24 hours. When taken out, the surface moisture should be dried off and the piece weighed; from the gain in weight, a good idea of the value of the stone may be obtained. One that increases 10 per cent. in weight in 24 hours should be rejected, unless it can be proved that such stone has endured successfully the tests of time and weather. Even one absorbing 5 per cent. of water and containing a large proportion of clay is unsafe to use.

27. Solubility.—To determine whether a stone contains much easily soluble earthy or mineral matter, crush finely a sample of the stone and place it in a glass of water, letting the particles remain undisturbed for about $\frac{1}{2}$ hour; then, give the contents of the glass a rotary motion by stirring. If the stone contains much earthy matter, the water will assume a turbid appearance, while if it has only a small quantity, the water will remain clear.

As already stated, the air in manufacturing cities is very likely to contain traces of various acids that attack the stone when brought in contact with it by rain. To determine the probable effect of acids on stone, soak a piece in a dish of water containing a drop or two of muriatic or sulphuric acid. If there is a very noticeable action, it will be wise to further test the stone.

STONE CUTTING AND FINISHING

28. Before treating of stone masonry, the preliminary work of dressing the stones for the wall should first be considered. While it is not necessary for an architect to be an expert stone cutter, he should be thoroughly familiar with the general principles of the art in order to be able to specify the proper treatment for a certain class of work and to know when it is well done

STONE-CUTTING TOOLS

29. In Fig. 1 are shown the various hammers used for cutting and dressing stone, which may be described as follows:

The **double-face hammer**, at (*a*), weighs from 20 to 30 pounds, and is used for breaking and roughly shaping the stones as they come from the quarry. The **face hammer**, at (*b*), is a lighter tool than the double-face hammer, but is used for the same purposes when less weight is required; it has one blunt and one cutting end, the latter being used for roughly dressing the stones preparatory to using the finer tools.

The **pick**, shown at (c), is used for coarsely dressing the softer stones; its length is from 15 to 24 inches, and the width at the eye is about 2 inches.

The **ax**, or **peen hammer**, shown at (d), is about 10 inches long, and has two cutting edges about 4 inches in

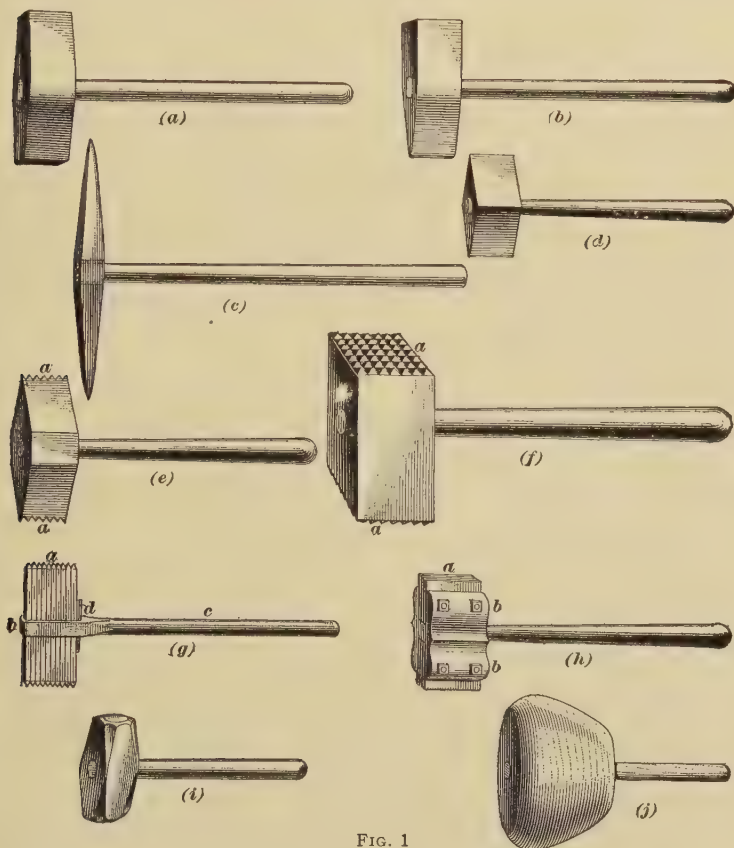


FIG. 1

length; it is used principally for making *drafts*, or margin lines, around the edges of stones, and also for dressing the faces, being used after the point, and before the patent hammer.

The **tooth ax**, shown at (e), has its cutting edges *a* notched to form teeth, the number of these teeth varying according

to the fineness of the work. It is used for roughing soft stones to an approximately flat surface before the finishing tool is used, but it is not used on hard stones, like granite and marble, as the points would become dull quickly and need constant sharpening.

The **bush hammer**, shown at (*f*), is from 4 to 8 inches long, with ends from 2 to 4 inches square and cut into a number of pyramidal points, as shown at *a*. This hammer is used for finishing limestones and sandstones after the surfaces have been made nearly even.

The **patent hammer**, shown at (*h*), is made of from four to ten thin blades of steel *a*, which are ground to an edge and held together by bolts, as shown at *b*, so as to form a single piece; it is used for finishing granite or hard limestone, and the number of blades required to give the proper fineness to the cutting is usually specified as four, six, eight, or ten cut.

The **crandall** is made as shown at (*g*), and consists of a malleable-iron handle *c* having a slot in the end *b*; in this slot are placed ten or twelve bars of $\frac{1}{4}$ -inch square steel *a*, about 10 inches long and pointed at each end, which are held firmly in place by the key *d*. The crandall is used to complete the finish of sandstone after the surface has been partly worked by a tooth ax or a chisel.

The **hand hammer**, shown at (*i*), is used for drilling holes and in pointing and chiseling the harder rocks; it is about 5 inches in length, and weighs from 2 to 5 pounds.

The **mallet**, shown at (*j*), is used when the softer stones are to be cut; it is made of wood, the head being about 7 or 8 inches in diameter and 5 or 6 inches in height.

30. Chisels.—In Fig. 2 are shown the different chisels used for dressing stone. At (*a*) is shown the **point**, which is made of round or octagonal steel, 8 to 12 inches long, with one end pointed; it is used for chipping off the rough faces of the stone and reducing them to approximately plane surfaces, ready for the peen hammer, and also to give a rough finish to stone in *broach* and *picked work*.

At (b) is shown the **tooth chisel**, used only on soft stones, and serving much the same purpose as the tooth ax.

At (c) is shown a **drove chisel**, 2 or 3 inches wide at the

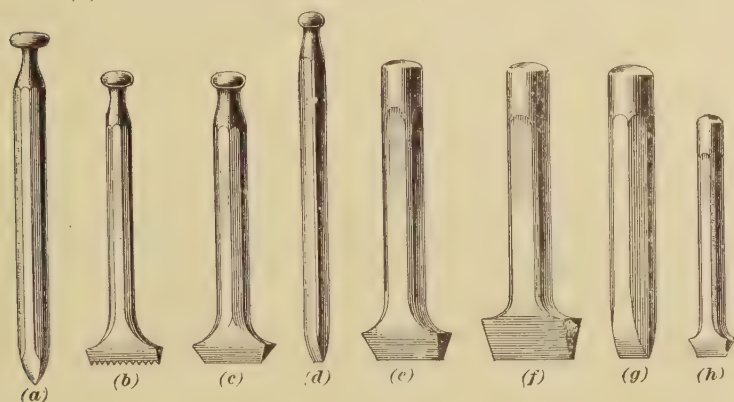


FIG. 2

end, which is used for cutting or driving the rough surfaces of the stone.

At (d), (e), (g), and (h) are shown other forms of chisels used for dressing soft stone.

At (f) is shown a **pitching chisel**, which is used for making pitched-face work.

31. Machine Tools.—Besides the hand tools just described, there are many machine tools employed to prepare the stone for the finer treatment to be given by hand work. These include *saws*, *cutters*, *planers*, *grinders*, and *polishers*.

The saws are either drag, circular, or band saws and each consists of a thin sheet of steel having blunt edges. The drag saw has a forward-and-backward movement, the cutting being done by the aid of sand and water fed into the cut. The operation of the others is similar, except as to the manner of driving.

The cutters are used on the rough stone to somewhat reduce the inequalities. Cutters and planers are made on two principles; one kind is used for homogeneous and tough stones, free from grit, etc., which are dressed by machines

resembling those used for iron and steel, and the other is for hard brittle stones whose structure necessitates a treatment resembling that employed in hand dressing. From the cutter and planer the stone goes to the grinder and polisher, which are practically alike, differing only in the fineness of the surface that they are capable of producing.

The polisher consists principally of a circular horizontal table on which the stone is fastened, the face to be polished being always turned upwards. This table with the stone revolves about a vertical axis through its center, and a metal plate that can be moved up and down, but will not revolve, is pressed on the stone. Sand and water are supplied between the plate and the stone, whose surface is thus abraded until the proper degree of smoothness is attained.

FINISH OF STONEMWORK

32. Stereotomy.—The art of making patterns, or templets, to which a stone is to be cut to fill a certain place in an arch or other complicated piece of stonework, is called **stereotomy**. The architect makes a drawing of the intended stonework, showing where the joints in the face are to be located, and the stone cutter then details each block and cuts it to fit exactly with the others. It is therefore important

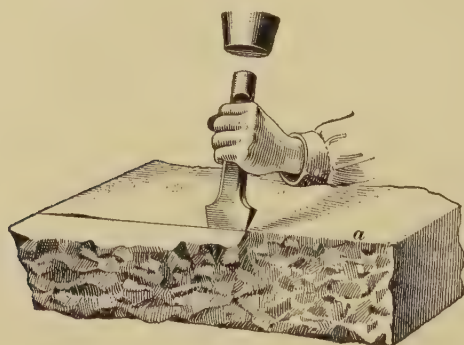


FIG. 3

for the architect to understand the different finishes to which stone is dressed, but it is not necessary for him to be able to make the templets for each stone.

33. Rock-Faced Work.—In Fig. 3 are shown **rock-faced**, or **pitch-faced**, work and the method of using the pitching chisel. The face of the stone is left rough, just as it comes from the

quarry, and the joints, or edges, are *pitched* off to a line, as shown at *a*. As very little work is required for this finish, rock-face dressing is cheaper than any other kind, especially when granite, bluestone, or hard limestone is used. Examples of rock-faced bluestone are shown in Figs. 4 and 5. Fig. 4 is a good specimen of *broken-range ashlar*, while Fig. 5 shows the general character of *coursed ashlar*. The different methods of laying up this work are treated in another Section.

34. Margins.—Building stones are often faced an inch or more from their edges. This dressed strip, which is shown in Figs. 7, 8, and 12, is known as the **margin**, or **draft line**. On soft stone, this margin is cut with a chisel, but on extra-hard stone, such as granite, it is usually cut with an ax, or peen hammer, in which case the surface would be plainer than the chiseled work and without the well-defined parallel channeling. The margin, or draft line, serves the purposes of emphasizing the joint, by contrasting the marginal plain surface with the rougher cut work in the center of the stone, and of giving a plain surface on which to work the angle of the joint, thus making a more true and accurate edge. Comparatively little margin work is now used for buildings. The feeling among architects is that the marginal tooling cuts up the texture of the stone and makes the work look too mechanical.

35. Pointed Work.—A pointed chisel is sometimes run over the face of a stone to knock off any large projections. This work is called **rough-** or **fine-pointed**, according to the number of times the work is gone over. In Fig. 6 is shown an example of rough-pointed work, while in Fig. 7 is shown an example of fine-pointed work.

36. Tooth-Chiseled Work.—One of the cheapest methods of working stone is known as **tooth-chiseled work**, which is done with the tooth chisel. A surface resembling pointed work, but not so regular, is thus obtained.

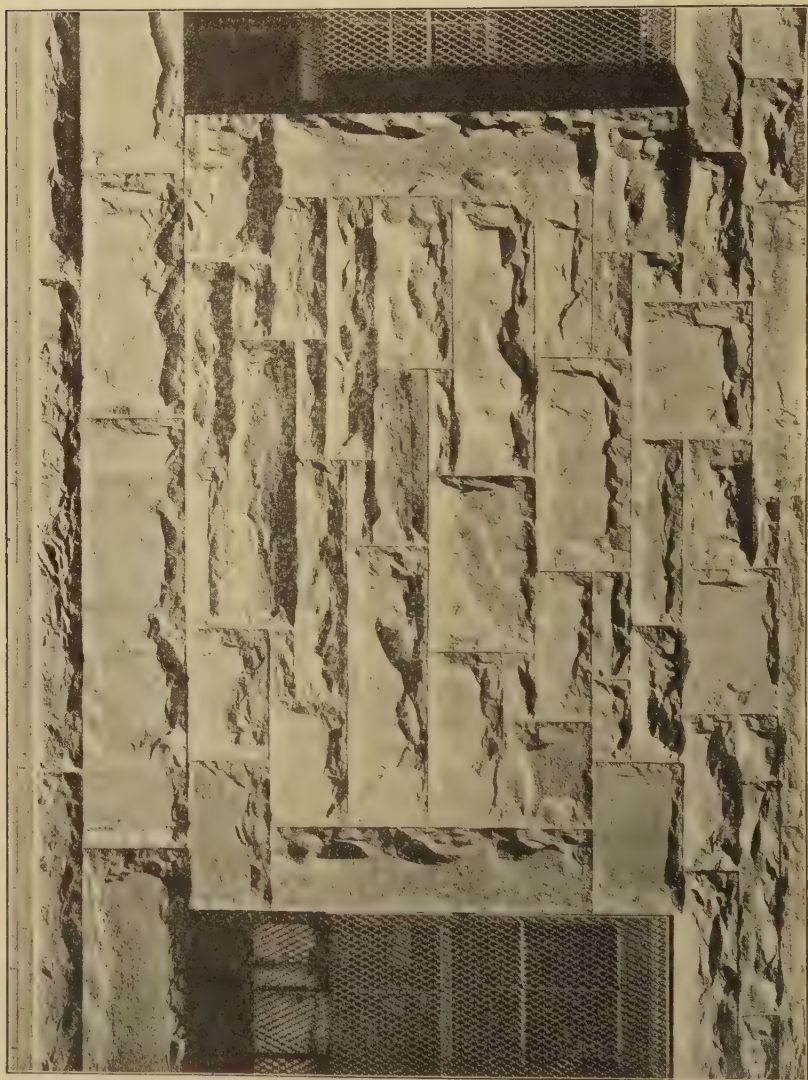


FIG. 4



FIG. 5



FIG. 6

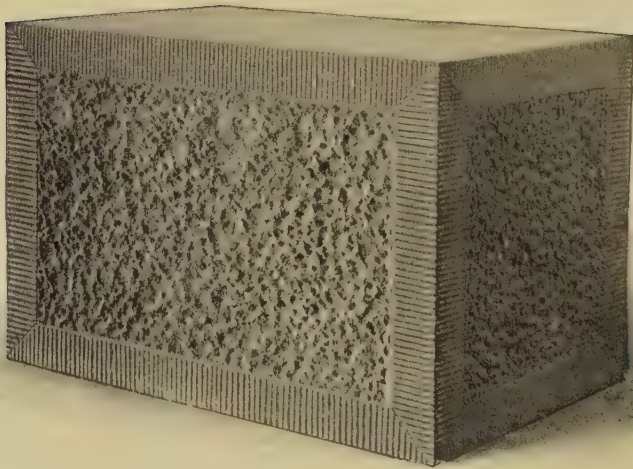


FIG. 7

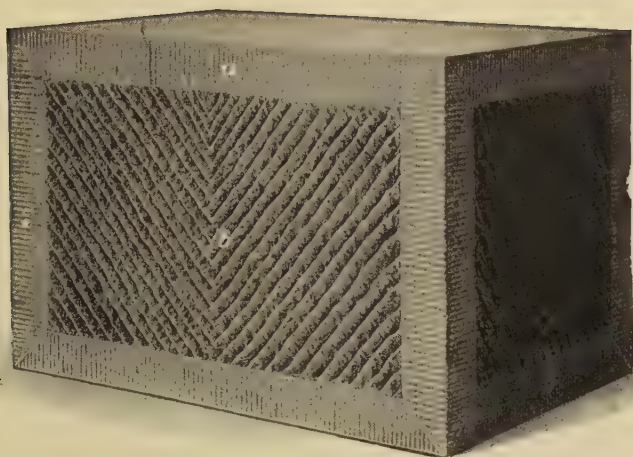


FIG. 8

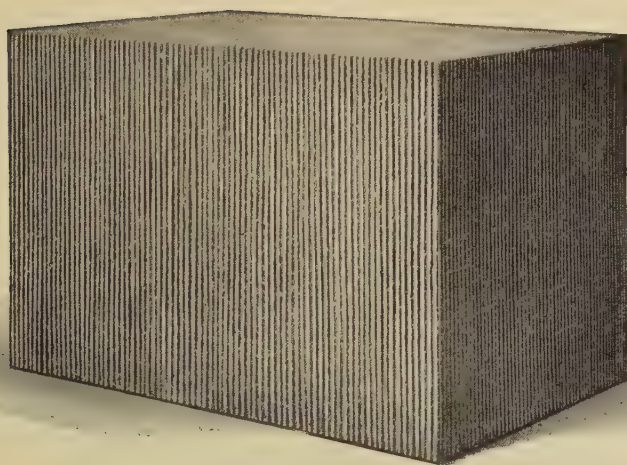


FIG. 9

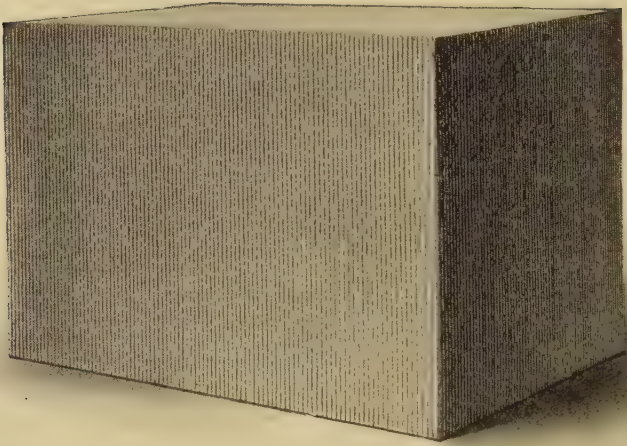


FIG. 10



FIG. 11

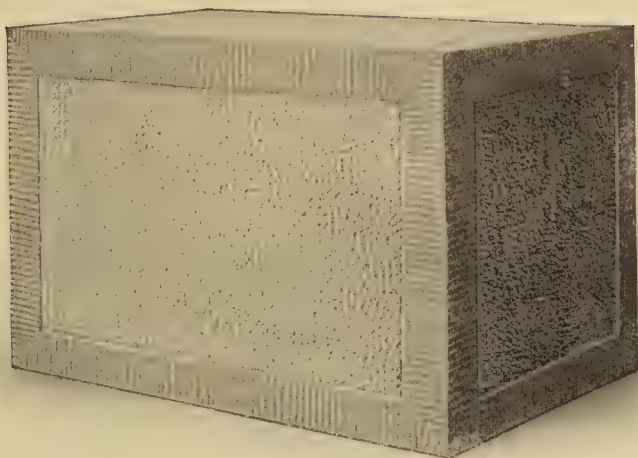


FIG. 12

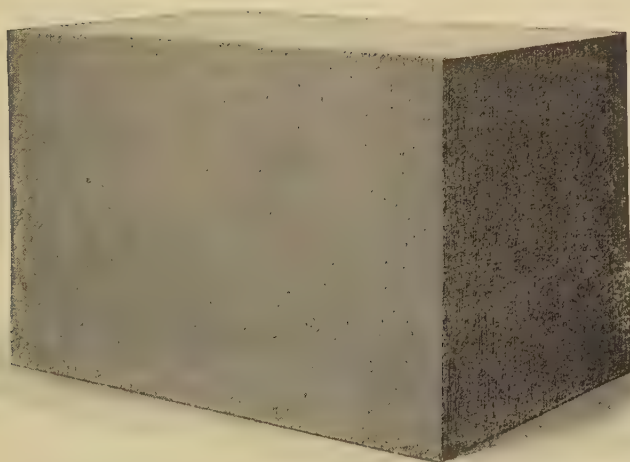


FIG. 13

37. Broached Work.—Fig. 8 illustrates what is known as **broached work**. In this kind of work, the stone is dressed with a point, so as to leave continuous grooves over the surface. At *a* is shown the margin, or draft line, and at *b*, the broached center, which is cut in opposite directions in order to illustrate right- and left-hand broaching.

38. Tooled Work.—For **tooled finish**, a tooth chisel from 3 to 4½ inches wide is used, and the lines are continued across the width of the stone to the draft line (when one is used). When well done, this work makes a very good finish for soft stones.

39. Drove Work.—**Drove work** is somewhat similar to tooled work, but is generally executed on harder stone. There are two general classes of this work; namely, *hand drove* and *machine drove*, the former being shown in Fig. 9, and the latter in Fig. 10. Machine-drove work, it will be noticed, is more regular, and at the same time the cuts are a little deeper, although this is hardly apparent from the illustration. For a large quantity of cutting, machine work is cheaper than hand work, but is not so pleasing in appearance.

40. Crandalled Work.—In Fig. 11 is shown **crandalled work**, which, when well done, gives the stone a fine, pebbly appearance. This finish is especially effective for the red Potsdam and Longmeadow sandstones. In the Eastern States, it is used for sandstones probably more than any other finish.

41. Rubbed Work.—Sandstones and most of the limestones are often finished by *rubbing* their surfaces until they are perfectly smooth. By continuing the rubbing long enough, granite, limestone, and marble can be given a beautiful polish. Rubbed work is finished either by hand, using a piece of soft stone with water and sand, or by a machine, which performs the same operation. If the rubbing is done soon after the stones are sawed into slabs and are still soft, it is cheaply and easily performed, as the sawing makes the face of the stone comparatively smooth.

42. Bush-Hammered Work.—In Fig. 12 is shown the finish of a stone after having been **bush-hammered**, which leaves its surface full of points; this makes a very attractive finish for hard limestones and sandstones, but should not be used on the softer kinds.

43. Patent-Hammered Work.—A stone finished by a **patent hammer**, which is generally used on granite and hard limestone, is shown in Fig. 13. The stone is first dressed to a fairly smooth surface with the point and then finished with the patent hammer. The degree of fineness in the finish is determined by the number of blades in the hammer, the usual number being eight or ten. The ax may be used instead of the hammer, but much more time is required to obtain an equally good finish.

44. Vermiculated Work.—In Fig. 14 is shown a stone having a somewhat elaborate finish, which is known as **vermiculated** from its worm-eaten appearance. Stones so cut are used principally as quoins and in base courses. Owing to the cost, this dressing is not often used in the United States, except for very expensive work.

A simple method of obtaining the vermiculated effect is by the use of a patented sand-blast process. The sand employed for this work is the dust of carborundum, which is one of the hardest substances known. This dust is blown against the stone with high velocity by means of compressed air. While this dust, or sand, will rapidly cut and wear away hard surfaces, such as stone, it will not cut soft, yielding surfaces, because the latter do not suddenly stop its motion, but, by giving way slightly, permit the sand to sink in a short distance and then rebound. For this reason, the nozzle of the blowing machine is made of soft rubber. On those portions that it is desired to have raised, the stone to be cut is protected with beeswax, asphalt, or even heavy paper, and the remainder of the face of the stone is eaten away by the blast. When the proper depth has been reached, the sand blast is stopped, and the paper or asphalt cover is removed. It is then simply necessary to put on a few finishing touches



FIG. 14

with a pointed chisel, and the stone is ready to go in the structure.

The sand blast is also used to clean stonework that has become soiled and stained by smoke and dust.

45. Scale Work.—A pleasing and novel method of stone dressing, presenting a striking effect of light and shade, is illustrated in Fig. 15. The finish shown at (a) is obtained by cutting out rows of shallow flutes between the drafts of the stone with about a 1-inch tool. The flutes are about an inch wide, and are alternated so that each successive course “breaks into” the preceding one and forms with

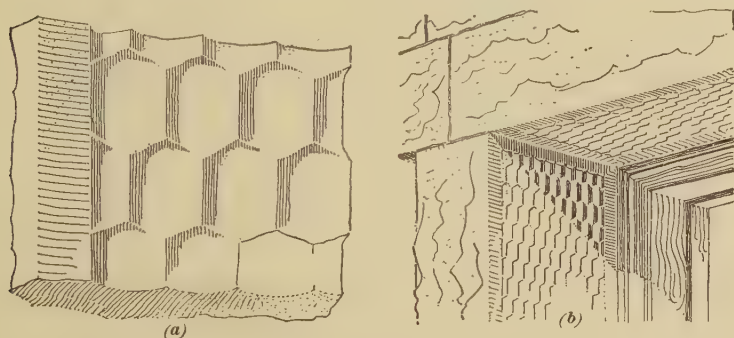


FIG. 15

it a series of hexagonal hollows, giving a honeycombed effect. The application of this finish to a window jamb is shown at (b).

This unique method is applicable, of course, only to soft stones, such as limestone; but to these it gives a beautifully crisp and varied surface. The cutting can be done either by hand or by machinery.

46. Rusticated Work.—Two examples of rusticated work are illustrated in Figs. 16 and 17, the former showing the stones with sharp edges and the latter the stones with rounded edges. The joint should always be at the upper edge of the rustication as shown at *a* in each illustration, as it is better protected from the weather when in this position. If the joint were placed at the lower edge of the rustication,

rainwater would lie on the lower horizontal surface and be liable to work its way back into the joint. The projection above the joint throws a heavy shadow at this point and strongly emphasizes the courses.

The height of the rustication should bear some simple proportion to the total height from joint to joint, and should not ordinarily be less than one-sixth of that height. The depth of the rustication should be about two-thirds of its height if the edges are square; if the edges are rounded, as in Fig. 17, the depth should be equal to the height. The

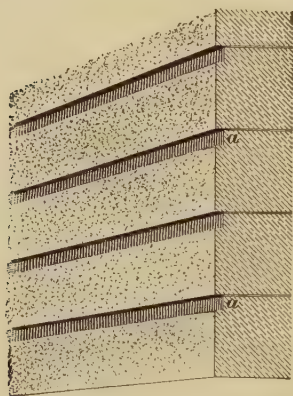


FIG. 16

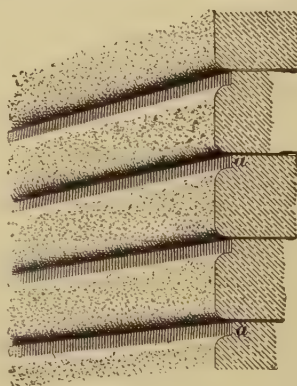


FIG. 17

rustication is sometimes obtained by **V** joints, wherein the edges of the stone are chamfered or splayed. Rusticated masonry is sometimes laid with close, vertical joints, but is more frequently laid with the vertical, as well as the horizontal, joints rusticated. The latter method gives the better effect when the stones are of good length.

Rusticated work is used in massive buildings, usually for the first story, forming a heavy base treatment strong in shadowed joints, on which is placed the lighter and more ornate upper stories, where the joints are close or, if rusticated, very much smaller than those below. The surface of rusticated stonework is usually dressed in such a way as to give a rough appearance; this may be done either in rough-pointed, fine-pointed, or vermiculated work, as shown in

Figs. 6, 7, and 14, respectively. These surfaces form a pleasing contrast with the plainer surfaces of the stones above. Good examples of rusticated masonry are to be seen in the Italian palaces of the Renaissance period.

CARVED WORK

47. In this Section, the preparation or cutting of stone surfaces has been taken up, and thus far has included rough rock faces and dressed faces, such as fine- and rough-pointed, patent-hammered, vermiculated, etc. The final step in the elaboration of stone is **carved work**. This requires more skill than common surface finishing, and in fact is an art requiring the skill of the sculptor. Carving is done both at the building, from scaffolds, and in the shop. Models in clay are frequently prepared, and plaster casts are made from these. The expert carver can reproduce the plaster model in stone with wonderful accuracy.

The scale and the minuteness with which carving should be executed depend on its height from the point or points at which it will be seen. Work that will be close to the eye of the observer should be carved out in great detail and fineness if the texture of the stone will permit, while work at some height from the eye should be bold and coarse in treatment to be effective. This latter point is often overlooked, and minute carving, beautiful in itself when viewed at close range, becomes a hazy maze when placed at such a height that its detail is practically lost.

The softer stones, being more easily worked, are more generally used for carving, as the expense is much less than when the granites and harder sandstones are employed. Great quantities of Indiana limestone are used for this purpose in the United States.

Besides figure work, carved ornament is utilized for the decoration of plain or molded band courses, capitals and bases of columns, pilasters, balustrades, friezes, panels, etc. Conventional or naturalistic plant growths usually form the base of the majority of ornamental motifs, but bands or

ribbons forming meanders and interlacings are much used in architectural work.

48. In Fig. 18 is shown an example of naturalistic carving in alto relief and in bas-relief. The forms used are plant and bird life. The two plants represented are the *Nuphar advena*, or water lily, and the *Typha latifolia*, or common cattail. Both of these motifs are copied closely from nature, and the detail is minutely carved, as the work is only a slight distance above the eye. The carving near the bottom of the panel is in alto relief and that in the upper portion is in bas-relief. The stone here used is marble, and the broad expanse of plain surfaces about the carving set off and frame it well. Owing to its rough texture and the size of its particles, coarser grained stone would not be suitable for such delicate carving.

49. In Fig. 19 is illustrated a similar panel in which the natural forms copied are the foliage and fruit of the oak and the mistletoe with squirrels perched on the limbs. This is a most beautiful piece of work and is very realistic. The distribution of the different treatments of relief is the same as in the previous example.

50. In Fig. 20 is shown a conventional scroll design that fills the entire panel in alto relief instead of a portion only, as in Figs. 18 and 19. In this respect, the carving is more in keeping with the panel moldings surrounding it, for these moldings are somewhat heavy for the bas-relief, as shown in Figs. 18 and 19. The design shown in Fig. 20 is a highly conventionalized acanthus, carved with great spirit. In respect to the harmony between the carving and the frame, this panel is the best of the three examples. The carving of the pilaster cap just above this panel is conventional, and repeats some of the leaf forms in the panel below.

51. A light type of rustication with panels of vermicular work is shown in Fig. 21. This example shows the effect of the vertical as well as the horizontal rustication. The cove carving of the cornice shows a treatment somewhat similar to





FIG. 18



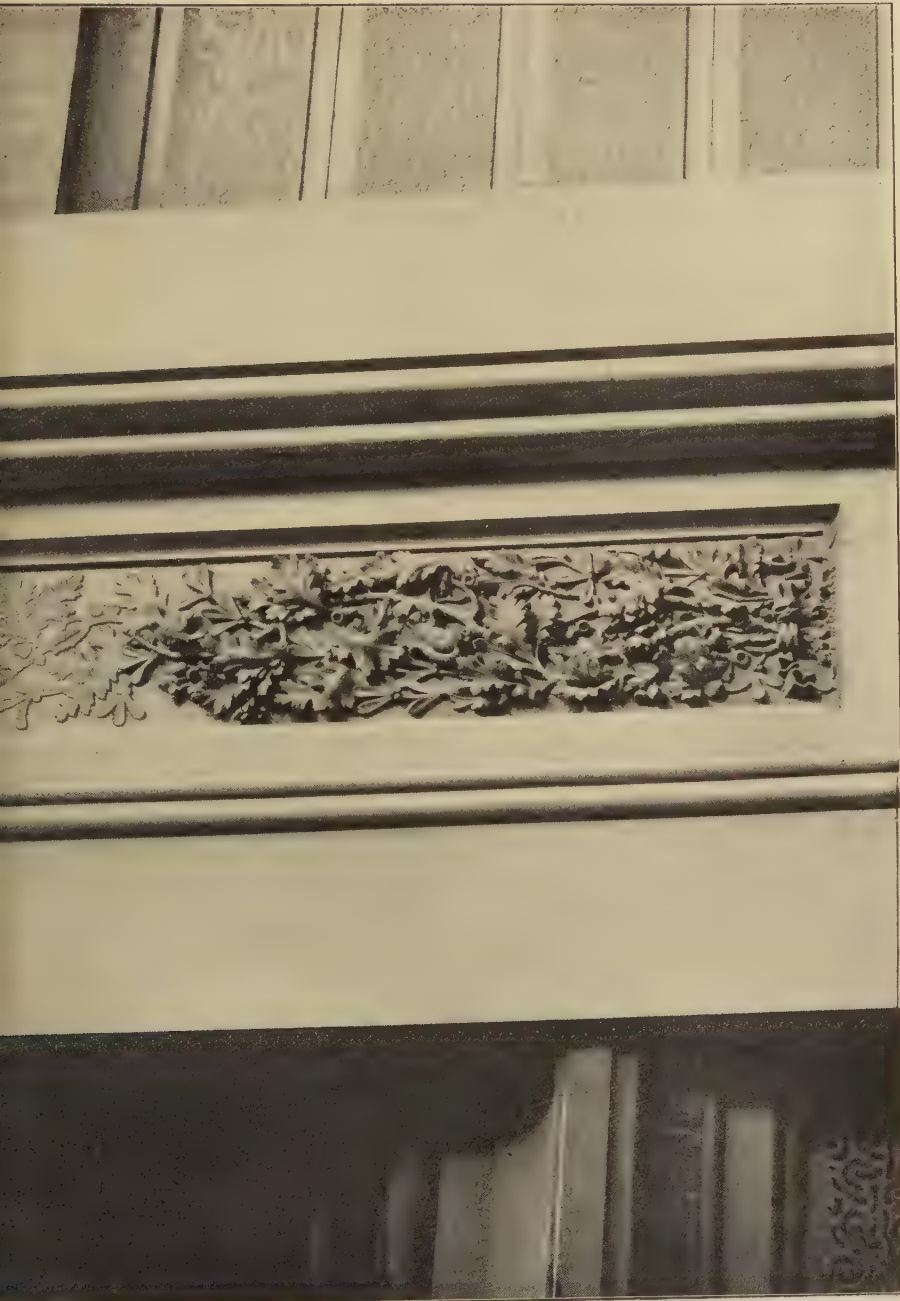


Fig. 19





FIG. 20





FIG. 22



FIG. 23

that of the pilaster in Fig. 20, although the carving is here done with much less snap and spirit. The scroll and the anthemion carved on the panel above the cove are conventional, as is in fact all the carving shown in this illustration. It would be difficult to say, except for the small leaf form in the scroll, which is based on the acanthus, from what the different forms here shown are derived. Figs. 14, 18, 19, 20, and 21 illustrate specimens of work executed on the City Hall of Philadelphia.

52. In Figs. 22 and 23 are illustrated two of the clustered columns in the Cincinnati Chamber of Commerce, designed by the late H. H. Richardson. The capitals of these columns are Romanesque, and are beautiful in design and execution. As will be observed, the carving is not very deep; this is due to the fact that the stone, which is granite, is exceedingly hard. These same capitals in a softer stone would be sharper and would have deeper cutting.

53. In Fig. 24 is shown the main entrance of the Temple Bethel in New York City, designed by Brunner and Tryon. This also is an example of Romanesque work, but is strongly Byzantine in feeling. All the carving here illustrated is quite close to the eye, and is most intricate and beautiful.

The adaptation of the Romanesque or Byzantine palmette, like the acanthus growth, to capitals, moldings, and plain surfaces is well illustrated here. Such work as that between the entrance tier of arches and the windows above, and that between the window arches and the large enclosing arch, would be lost if placed another story higher. In its present position, the work stands out clear and sharp. The rock face of the ashlar surrounding this elaborate doorway serves as a foil for the rich arabesque within the arch.

54. The entrance to the Cable Building, New York City, designed by McKim, Meade, & White, shown in Fig. 25, is an example of stonework where sculpture, the sister art to stone carving, is used in connection with the conventional plant growths, moldings, etc. already described and illustrated. The two draped figures in this example are quite



FIG 24



close to the eye, and are therefore carved with considerable exactitude and detail. It is probable that these figures were carved from scaffolds at the building, after plaster models that had been previously approved by the architects. Note the beautiful, delicate carving of the Ionic capitals and cornice and the architrave above the door. This entrance is Greek in its inspiration, and the carving has been done with all the dainty grace and feeling of that style.

LATHING, PLASTERING, AND TILING

INTRODUCTION

1. **Plastering** may be described as a process by which the structural members composing the skeleton of the building fabric are clothed with plastic material that will render the structure more agreeable and habitable. This process is applicable to both the exterior and the interior of the structure. When used for exterior work, as in overlaying an inferior grade of stone or brick masonry, or in forming the covering material or wall sheathing to protect the framework, it is usually classified as **stucco work**.

2. Improved processes in the manufacture of brick and terra cotta, increased facilities for handling and cutting stone, and the desire for truthful construction, have all acted to drive stucco work out of the field. So strongly has this reaction influenced the public mind that the term stucco has become synonymous with everything that partakes of a spurious construction and fraudulent concealment. This change in public taste has practically limited the exercise of the plasterer's art to interior work. In this restricted sphere, however, there is ample opportunity for the exercise of good, honest, and skilful work, as no other substance has yet been produced that so well satisfies the requirements in the treatment of the large areas that occur in interiors.

3. The natural march of progress, and especially the introduction of modern fireproof construction, has led to the development of new methods and the improvement of old ones, so that at present the art of plastering has reached a high degree of perfection. To obtain such results, the prime requisites are good material and good workmanship. As these depend greatly on the specifications, the architect should be well acquainted with the nature and qualities of the materials and the proper methods of performing the work, in order to be able to make such specifications intelligently and to see that they are properly carried into execution.

4. **Preparation of Walls for Plastering.**—As plastering consists in coating the surfaces of walls and ceilings with thin layers of a plastic material, the surface to be covered should present every facility for the perfect adhesion and retention of the material that is to be applied. Generally speaking, there are only two kinds of bases that are coated with plaster and built up with subsequent layers to form a mass of sufficient thickness to withstand pressure and to retain a true and uniform surface. The first may be called a *lithic*, or *stone*, *base*, and the second, a *grille base*. In the former case, the plaster is laid directly on the face of the naked wall, which may be of either stone or brick; in the latter case, it is spread over a grille-like arrangement of wooden or metal strips, the edges of which are sufficiently separated to allow mortar to pass between them and fold over on the inner face, thus forming a *key*, or continuous clinch, that will effectually hold the mortar in position.

5. **Lathing** is the general term applied to the grille base just mentioned, and, as a rule, consists of wood in non-fireproof buildings, like ordinary frame dwellings, and of metal in fireproof structures. Although not absolutely necessary on brick and stone walls—as plaster adheres well to such surfaces—it is usually better to have some kind of lathing on exterior walls built of masonry. By this means, the plaster slabs are isolated from the wall, and a clear air space

intervenes. This arrangement insures a continually dry surface, which would otherwise be liable to dampness from the condensation of the heated air of the room on the cold surface of the walls, or from moisture penetrating the body of the wall during a period of wet weather.

The laths for exterior brick or stone walls are usually attached to vertical strips, 1 inch thick by 2 inches wide, called **furring**, which have been fixed to the walls by the carpenter; these strips are set at 12- or 16-inch centers, according to the grade of the work. For the interior walls in frame buildings, the laths are attached directly to the studs, or vertical posts, that form the framing of the walls. The laths for ceilings may be nailed directly to the under edges of the joists, or they may be attached to *cross-furring*—a series of strips, similar to those used on the walls—arranged at right angles to the joists and fixed at 12-inch centers; better results are obtained by the latter method, as the warping of the joists does not so much affect the lath.

LATHING

WOODEN LATHS

6. In old work, laths were generally made of oak, but in current practice, pine, spruce, and hemlock are used. The regular size of the lath strips is $\frac{1}{4}$ in. $\times$ $1\frac{1}{2}$ in., and 4 feet in length; this length regulates the spacing of the furring strips, studs, and joists in order to prevent waste of material.

Laths may be either split or sawed; split laths are better, as there are no cross-grained fibers to reduce their strength, while the presence of the cross-grained fibers in sawed laths makes them liable to curl and warp, due to the absorption of moisture from mortar. However, owing to their cheapness, sawed laths are generally used in the United States. To avoid the warping already mentioned, the laths should be straight-grained; to insure durability, they should be well seasoned

and free from any appearance of sap, rot, or incipient decay; for strength, they should be clear of shakes and large or loose knots; and to prevent the subsequent discoloration of the plaster, the laths should be free from live knots and resinous pockets.

Laths are sold by the thousand, which will cover about 570 square feet, estimating $1\frac{3}{4}$ laths to the square foot. A fairly good workman will put on from 1,200 to 1,500 laths in a day of 8 hours if they are single-nailed

7. Laths are nailed in place in parallel rows, the edges being kept fully $\frac{1}{4}$ inch apart, so as to enable soft plaster to be pressed through and form a key. The ends of the laths should not lap over one another, but should be butt-jointed and flush. Continuous joints should not occur on one support, but the lathed surface should be divided into panels from 15 to 18 inches in width and the joints made to break on alternate supports, otherwise continuous cracks in the plaster will be liable to form. Laths are usually attached to joists and studs with cut or wire nails, about $1\frac{1}{8}$ inches in length and having large flat heads, one nail being used at each support. Work is made more solid by using two nails at each support, and in either case it is more safe that two nails should be used in each end of every lath. The nails should be galvanized, to prevent moisture from rusting them, which would cause large yellow patches to appear on the surface of the plaster. Where Keene's cement and plasters of similar composition are applied, copper nails must be used, as these plasters contain ingredients that will make iron nails rust rapidly.

Where joists or studs are over 2 inches in width, a strip should be attached to them, so as to keep the laths clear of the wide surface and enable the plaster to form a key. Nails are sometimes thickly studded over wide surfaces of wood, such as beams, the plaster clinch being formed around the heads of the nails; but, where practicable, two thicknesses of lath nailed to the beam at right angles to one another will give better results. The practice of closing

angles and narrow spaces with laths placed vertically should not be allowed, as an imperfect key is formed by the weight of the mortar causing a downward flow of its substance.

8. Sheathing Laths.—A combined sheathing and lath, known as **sheathing lath**, is illustrated in Fig. 1. These sheathing laths have been used to some extent, and while more costly, are excellent substitutes for ordinary laths. They consist of $\frac{7}{8}$ -inch boards, 8 inches in width, cut in

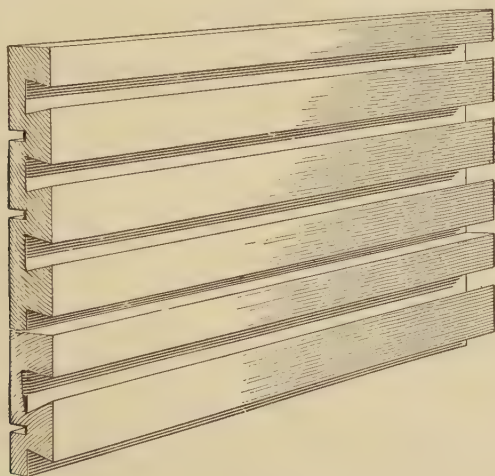


FIG. 1

uniform lengths and grooved as shown. Such sheathing laths are especially valuable when the outer walls of wooden buildings are to be *back plastered*. This may be accomplished by nailing the sheathing laths, grooved side inwards, to the outside of the studs and then applying plaster between the studs. This method makes a very warm house, but when a second thickness of plaster is used inside of the studs, it is much more expensive than ordinary plastering. These sheathing laths are also used for inside work, and require less mortar than the common lathing. Nails can be driven anywhere in them without danger of loosening the plaster.

METAL LATHS

9. Steel in the form of wire netting and of expanded and perforated metal laths has come into very extensive use for the support of plastering, especially in fireproof structures. Plaster becomes more firmly attached to metal than to wood and will not become loosened by ordinary accidents, and as the steel is more or less completely embedded in the plaster, the plaster protects it effectively from fire, whereas wooden laths are only partially covered. Apart from the fireproof qualities, metal laths are valuable in wood construction from the fact that plaster laid on them will not crack nor fall off should shrinkage occur in the woodwork; and if the laths are set away from the joists and studs, these timbers will not show through the plaster, as is generally the case when plaster is laid on wooden laths.

Probably the best fireproof lathing consists of strong wire cloth stretched tightly over metal furrings. The difficulty of properly stretching wire cloth is one of the objections to its use, for unless the netting is quite rigid, it will yield considerably as the coats of plaster are applied; however, manufacturers now furnish stretchers, the use of which obviates this difficulty to a great extent. The objection has also been raised that both wire and expanded-metal lathing require much more plaster than wooden lathing. In this fact lies their great value, for, as the mortar is the fireproofing material, the lathing should be completely embedded in it; otherwise, the metal is perhaps of no greater value than wooden lathing. Numerous severe tests, both experimental and in actual fires, have demonstrated that plaster—especially the hard kinds—applied to wire cloth will successfully protect woodwork from fire if the wood is completely covered with it.

Wire laths may be had in numerous sizes; the size most extensively used has about $2\frac{1}{2} \times 2\frac{1}{2}$ meshes per square inch and is made of No. 20 gauge wire. It comes in rolls from 32 to 36 inches wide, but some manufacturers supply it in widths up to 8 feet. Metal laths may be had either plain,

painted, or galvanized. The latter form, while more expensive, is preferable, as it is much stiffer and less liable to rust than the plain kind. Painted laths are nearly as good as the galvanized, and cost considerably less.

10. Furring.—Wire lathing and plaster used to protect woodwork should not be in contact with the latter, but should be separated at least $\frac{1}{4}$ inch, while more space is advantageous. To secure this space, furring strips are necessary. These strips may either be woven into the wire cloth or be separate pieces fastened to the wood before the lathing is applied. In the latter case, the strips consist of corrugated or flat iron of proper width to give the required air space when set on edge—usually about $\frac{1}{2}$ or $\frac{3}{4}$ inch—and are fastened to the wood by small staples. The strips generally run lengthwise of the floorbeams and studding; if laid crosswise, they will not have such a firm bearing, and should either be placed closer together or heavier strips should be used.

A substitute for this kind of furring is made of $\frac{1}{8}$ -inch rods spaced from 6 to 8 inches apart. These rods are kept away from the wood by separators made of small pieces of thin metal having the ends turned up from $\frac{1}{2}$ to 1 inch at right angles to the back, which is slotted to permit the insertion of staples. This furring should run across the joists, or studs, and the rods may be placed as close together as required.

11. Stiffened Wire Laths.—The use of separate furring strips forms an item of expense that may be avoided by substituting wire laths having ribs attached or woven into the cloth for plain wire laths. The first mentioned are called the *Clinton stiffened laths*, which consist of narrow strips of corrugated steel fastened to the netting at 8-inch intervals, crosswise to the length of the roll, by means of metal clips. The laths are nailed to the floor joists or studs with the strips next to the wood.

The second kind referred to are the *Roebling laths*. These laths are formed of ordinary wire cloth having V-shaped stiffeners woven into the cloth at distances of about 8 inches.

These ribs are made of sheet iron, and vary from $\frac{3}{8}$ inch to $1\frac{1}{2}$ inches in depth, the former being the standard size. The

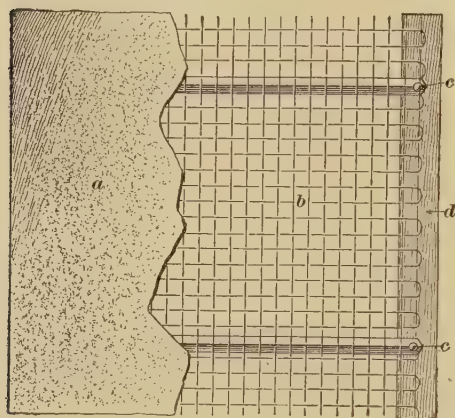


FIG. 2

a represents the plaster; *b*, the wire cloth, stiffened by the strips *c*, which are attached to the woodwork *d* by sharp-pointed nails driven through the point of the **V**.

12. Expanded-Metal Laths.—Fig. 3 shows a kind of metal lath that is made from thin sheets of soft tough steel. The sheets are first slit and then expanded so that a diamond-shaped mesh is formed, the width of the strips being turned nearly square to the surface of the sheet. This

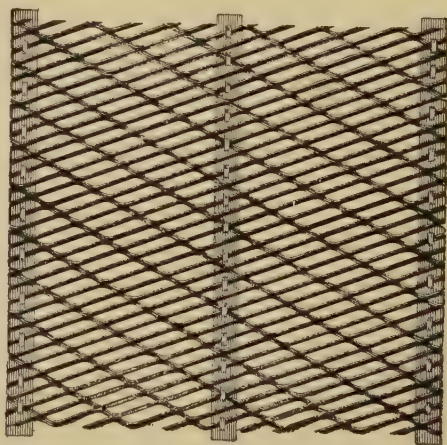


FIG. 3

style of lath may be had with various sizes of meshes ($\frac{3}{16}$ in. $\times$ $1\frac{1}{4}$ in. being commonly used), and in sheets from 14 to 20 inches in width and 8 feet long; the thickness of the lathing

larger sizes are used for furring exterior walls, to provide greater air space. The wire cloth is made with $2\frac{1}{2} \times 2\frac{1}{2}$, 3×3 , and 3×5 meshes per square inch, the first being the usual size for lime-and-hair mortar, and the others being used with hard plasters.

In Fig. 2 is shown the Roebling lath;

is barely $\frac{1}{4}$ inch. These laths possess considerable stiffness and do not need stretching; they can be fastened directly to the floor joists and studding, but when laid on boards, metal furring should be interposed. The lathing is stiffer when placed so as to have the long diagonals of the mesh at right angles to the studding, to which it is fastened by 1-inch staples.

13. Perforated sheet-metal laths are made by corrugating, or ribbing, sheets of thin steel or iron and punching out, or expanding, some of the metal between the ribs, in order to afford a good clinch for the plastering. There are a number of kinds, but the general appearance is similar to that shown in Fig. 4. The usual size of the sheets is 8 feet long by from 16 to 24 inches wide. These laths are much easier to put on than wire cloth, and can be applied as quickly as wooden laths, being especially easy to bend to fit corners (where the laths should never be cut, but continued to the next stud beyond the angle, so as to stiffen the wall and prevent cracks at the corners). The laths are fastened by means of barbed nails. The nailing should be started at the middle of the sheet and continued to the ends, in order to make the laths set firmly on the woodwork.

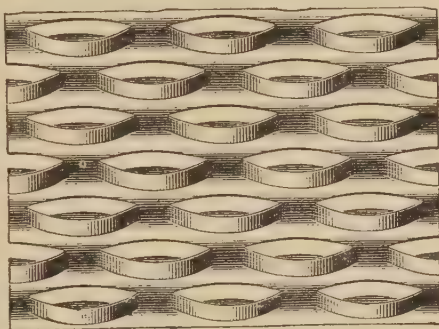


FIG. 4

Fig. 4 shows one of the best known and most satisfactory metal laths, which is called the *Bostwick*. They are made of ribbed sheet steel, having considerable of the metal between the ribs cut and curved out. The openings are $\frac{3}{8}$ in. $\times$ $1\frac{3}{4}$ in., and the ribs are spaced $\frac{3}{4}$ inch apart. These laths should be put on with the raised side outwards.

14. Metal Laths in Wood Construction.—While metal laths are preferable to wooden laths for ordinary

frame structures, the additional cost generally precludes their use; but even in such buildings, there are numerous places where metal laths may be of considerable advantage, while the increased expense is not very great. For example, cracks at corners of ceilings and partition walls can be largely prevented by bending a strip of wire cloth, or lath, to fit the angle, and nailing it to the joists or studs on either side. Another place where metal laths should be used is at the junction of a wooden partition and a brick wall, when there is no furring on the wall and especially when the partition is flush with it. If a strip of metal lath is lapped 12 inches on both wall and partition, cracks at the junction will be avoided. When plaster is applied to exterior brick walls having wooden lintels, difficulty is sometimes experienced from the plaster cracking at the joint or not sticking to the wood. To obviate this, the joint should be covered with a strip of metal lath fastened to both brickwork and lintel. The foregoing uses are only a few of the numerous valuable applications of metal lathing to wood construction; others will doubtless suggest themselves.

PLASTER BOARDS

15. Plaster boards are made of alternate layers of calcined gypsum, or plaster of Paris, and strong fibrous felt. They are used as a substitute for lathing and the first coat of plastering. They are made in sheets 32 in. $\times$ 36 in. in size and $\frac{1}{4}$ inch and $\frac{1}{2}$ inch in thickness. The outer surfaces are of felt, which forms a perfect bond with the plastering mortar. These boards can be readily sawed and nailed, and are fastened directly to the studs, furring, and joists by means of flat-headed nails. The boards should be set so that there will be a space of $\frac{1}{4}$ inch between them and so as to break joints horizontally on the walls. The advantages claimed for these boards are that they are non-conductors of heat and cold, are fire-resisting, that they save the expense of the lathing and first coat of plaster, and keep dampness due to plastering away from the woodwork.

PLASTERING

PLAIN PLASTERING

MATERIALS

16. Up to quite a recent period, practically all the interior plastering in the United States was composed of lime, sand, and hair. When plaster is made of a good quality of lime that is well slaked and properly mixed with the other constituents, it is very durable; but much of the lime plaster now used is made of inferior materials, so that a great deal of it is practically valueless so far as durability is concerned.

The substances that enter into the composition of the mortar will depend on the nature of the surface to be coated, the order in which the layer is applied, and on the desired finish. For ordinary work, these are *lime, water, sand, hair, and plaster of Paris*.

17. Lime.—Many limes that make good mortar for other purposes, are unfit for use in plaster, as they contain more or less overburned hard lumps that resist the action of the water and fail to readily disintegrate. Eventually, these overburned particles will slake, or what plasterers call “pop,” and cause small pieces of plaster to fly off. Walls and ceilings may sometimes be seen pitted all over from such checking.

In many places, a number of brands of lime may be had, and, unless the slaking qualities are known, care should be exercised in selecting one for plastering purposes. In any case, the best practice is not to use lime until it has been slaked at least a week, as even with the best limes considerable time is required for the slaking of all the particles.

Lime is frequently sold by weight in the Western States, but elsewhere it is usually put up in barrels and sold by measure.

18. Sand.—Sand for making plaster should be angular, of medium fineness, and free from earthy matter. Before using, all sand should be well screened, to remove the coarse particles, and if wanted for hard finish, it should be sifted. The best plaster is made of sand that is screened, washed, and dried. In most cases, the sand is merely screened river or pit sand; the first is the better, as the water has washed away most of the clayey matter, which pit sand is likely to contain. There are the same objections to using sea sand for plastering mortar as for other mortar.

19. Hair and Fiber.—Hair and fiber are used in plaster for the reason that ordinary lime mortar does not possess sufficient cohesive power to bind it together firmly. Hair is used almost exclusively for this purpose, but in the Eastern States, Manila fiber cut into short pieces is frequently substituted. The patent ready-mixed mortars usually contain either Manila jute or asbestos as a fibrous material. Cattle hides are the chief source from which plastering hair is obtained. After being cleaned from grease, the hair is washed and dried and then packed into bags that will hold a bushel (measured loose) and weigh from 6 to 8 pounds when filled. The hair of salted hides is undesirable, owing to the presence of salt, which is not easily extracted. Goat hair, when it can be had, is preferable to cattle hair, as it is longer and of better quality.

20. Plaster of Paris is obtained by the heating of a crystalline limestone called *gypsum*, which is classified as a hydrated sulphate of lime, its constituents being water, salts of sulphuric acid, and lime. Extensive deposits of this stone exist near Paris, France, from which fact the trade name is derived. The chief value of this plaster is that paste made from it sets rapidly and within a few hours acquires its full strength. Plaster of Paris is very soluble

in water, which renders it unfit for external use; but it is invaluable for cornice moldings and enrichments, and is also used in several plastic mixtures. Its volume expands slightly in setting, and on this account it is a good material for filling chinks and holes in repair work. Plaster of Paris is much used for making casts, etc., which are generally molded hollow, owing to its liability of cracking when formed into pieces of any considerable thickness. When plaster of Paris is mixed with lime mortar, in which case the lime mortar is said to be *gauged*, the setting takes considerably less time than that of pure lime mortar.

PLASTERERS' TOOLS

21. The implements used by the plasterer are simple and inexpensive; the principal ones are shown in Fig. 5.

At (*a*) is shown an ordinary **screen**, which is used for separating the coarser particles of sand and gravel from the finer ones. At (*b*) is shown a screen through which the slaked lime is passed to free it from gritty or unslaked particles. For very fine division, small wire and hair sieves are sometimes employed.

The **mixing box** is a platform of rough boards battened on the bottom and having sides 10 or 12 inches high, making a water-tight box, in which the lime is slaked and the materials mixed.

The **hoe** and the **shovel**, shown at (*c*) and (*d*), respectively, are used for mixing the materials.

The **hawk**, shown at (*e*), is a piece of board about 10 inches square, provided with a short handle. It is used to hold small quantities of prepared mortar, or stuff, ready for applying with a trowel.

The ordinary **laying trowel**, shown at (*f*), is used for applying plaster to the walls. It is a thin plate of polished steel, about 10 inches long and $4\frac{1}{2}$ inches wide, having a wooden handle. Various other forms of trowel, for gauging, pointing, etc., varying in length from 3 to 7 inches, are shown at (*g*), (*h*), and (*i*).

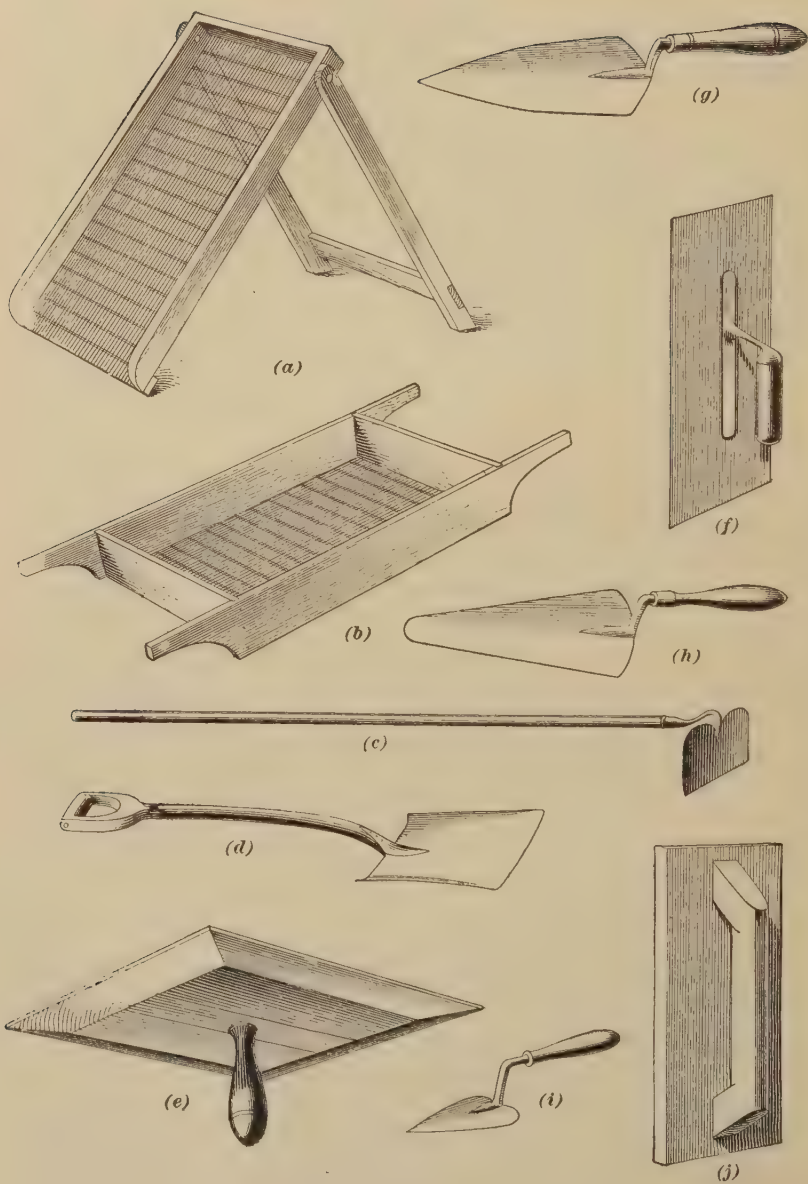
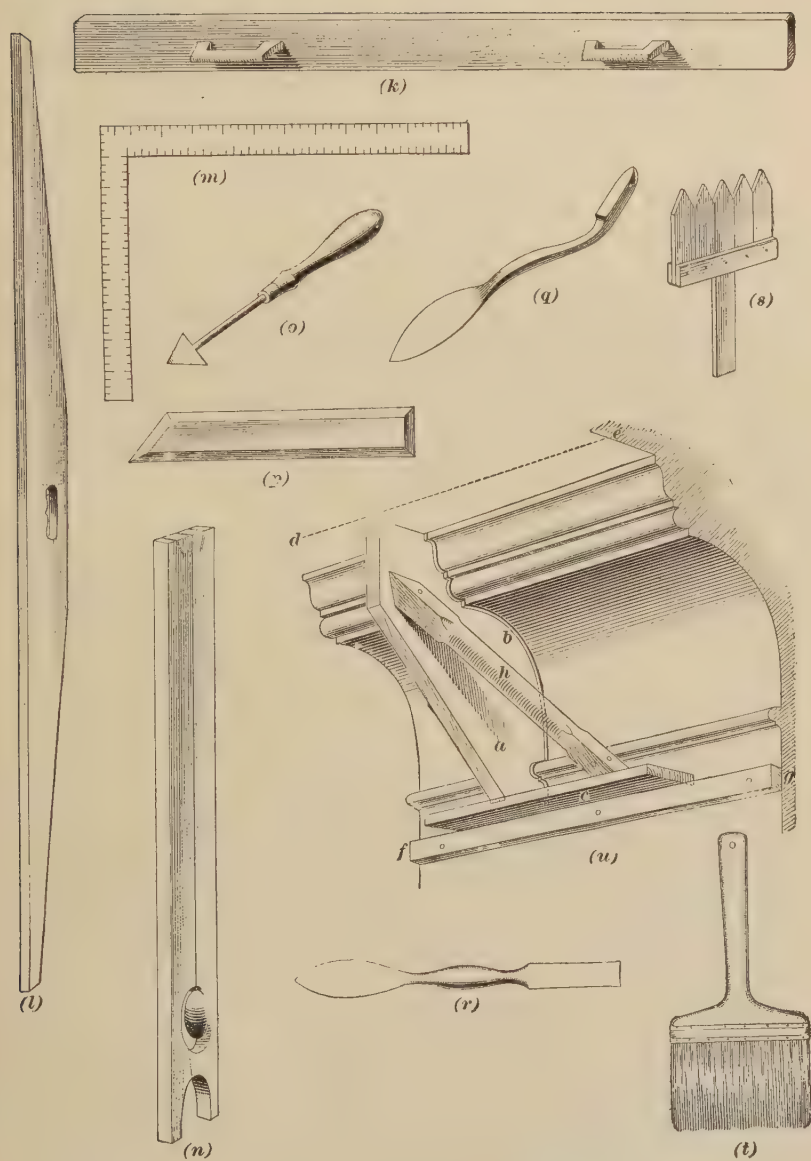


FIG. 5



Floats are used for smoothing, or floating, the surface of the second coat. At (*j*) is shown the **hand float**, which is merely a piece of board with a handle on the back. It is usually made of pine, but for producing the finished surface of very fine work, a cork face is sometimes used. For rough finish, the face of the float is often covered with carpet, etc. A two-handled float, called the **derby**, is shown at (*k*); this is a straightedged piece of wood, usually from 3 to 6 feet long, and is used for floating larger surfaces than can be readily worked with a one-handled float.

The **straightedge**, shown at (*l*), is a long piece of smooth board, having its under edge planed straight and true. It is used to test the walls and ceilings, in order to obtain plane surfaces.

The **square**, shown at (*m*), is used for testing the true-ness of angles.

The **plumb**, shown at (*n*), is used to determine the perpendicularity of the surfaces by applying one of its straight sides to the surface. If the plumb-line, hanging freely, lies along a shallow groove cut into the face, parallel to the sides, the edges are true.

Jointing and mitering tools, shown at (*o*), (*p*), (*q*), and (*r*), are used for picking out and finishing angles and miters in moldings, etc.

The **comb**, shown at (*s*), is used for scratching the surfaces of the first and second coats of plaster, to form a good key for the ensuing coat. It consists merely of pieces of lath nailed together, and having one end sharpened, as shown.

Brushes of various kinds are used by the plasterer. That shown at (*t*) is used for dampening the surface of the plaster while it is being worked smooth.

Templets of various kinds are used for forming cornices and moldings. The templets are made of wood or sheet metal cut to the required outline, and are backed by wood. At (*u*) is shown one form of templet, which consists of a board *a*, to the beveled inner edge of which is attached a thin zinc or steel plate cut to the outline of the cornice, as at *b*. The strip *c* and handle *h* brace the board *a* firmly and keep

it square with the wall; fg represents a guide strip on which the strip c slides, and de , a line drawn on the ceiling flush with the outer edge of the board a , which is always kept along this line.

PROPORTIONS OF MATERIALS

22. The quantity of thoroughly slaked-lime paste that a barrel of ordinary lump lime will yield is about 2.75 barrels. The voids in sharp and clean sand are about one-third of its bulk. Probably the best plastering mortar is obtained by using sufficient lime paste to fill the voids in the sand $1\frac{1}{2}$ times; that is, the lime paste should be $\frac{1}{3} + \frac{1}{6} = \frac{1}{2}$ the volume of the sand, or one part of lime paste to two parts of sand. Measured in barrels, the lime (unslaked) and sand should be in the ratio of 1 to about $5\frac{1}{2}$. If lime is sold by weight, the same result will be had by using $2\frac{1}{2}$ barrels of sand to 100 pounds of dry lime. For 100 square yards of plastering laid $\frac{3}{8}$ inch thick, it will require, according to these proportions, about $2\frac{1}{2}$ barrels of lime and 14 barrels of sand. For the best class of work, the quantity of hair used should be $1\frac{1}{2}$ bushels to 1 barrel of lime for the first, or scratch, coat, and $\frac{1}{2}$ bushel to 1 barrel for the second, or brown, coat. Generally, however, plastering mortar contains less lime and hair than just stated, although these proportions are not too much for first-class work

To regulate the proportion and uniform mixing of common plaster, unless the operations are constantly watched, is a difficult matter. The ordinary method of mixing is to add as much sand to the slaked lime as the mixer thinks it will stand, and it is hard for the architect to determine whether or not there is too much sand. Considerable experience, however, will enable one to judge the quality of the mortar by its appearance, or by trying it with a trowel when ready for use.

23. For a scratch and a brown coat on wooden laths with $\frac{3}{4}$ -inch grounds, the following quantities are generally allowed for 100 square yards: 1,500 to 1,600 laths; 10 pounds

of three-penny lathing nails; $2\frac{1}{2}$ barrels, or 500 pounds, of lime; 45 cubic feet, or 15 barrels, of sand; and 4 bushels of hair. For the best quality of white coat, the estimate is 90 pounds of lime to 50 pounds of plaster of Paris, and 50 pounds of marble dust. The same proportions can be used for large or small quantities.

MIXING PLASTERING MORTAR

24. Hand Mixing.—Outside of a few large cities, the great bulk of plastering mortar is mixed by hand, and for the best results requires very close regulation of materials and careful manipulation. The mixing should be performed as much as possible outside of the building to be plastered, so as not to make the interior damp from the vapor of slaking lime. When mortar is mixed in cold weather, it should be done under shelter, and in no case should frozen mortar be used.

A good quality of lime having been selected, it is slaked with clean water in a tight box, and allowed to stand for at least 24 hours—a week is better—to allow all the particles to be acted on. If there is any residue after slaking, the lime paste should be run through a fine-wire screen into another box. By using this paste as the base, the various coats may be made by adding other materials. The mixtures are generally classified as *coarse stuff*, *fine stuff*, *blasterer's putty*, *gauged stuff*, and *stucco*.

25. Coarse stuff is used for the first, or scratch, coat, and is made by mixing the proper quantities of sand and well beaten-up hair with slaked lime that has been reduced to a thin cream-like paste. (The sand is usually added last, but some authorities claim that better and tougher mortar is made by adding the sand soon after slaking.) On government work, the specifications require that the hair shall not be mixed with the lime paste until the plaster is to be applied. The materials are thoroughly incorporated by means of a hoe and then piled in a heap for a week; after which sufficient

water is mixed with the mortar to give it the proper consistency. Only a small batch should be wet at a time, and this should be laid on the lathing at once.

The common method is to mix the hair and sand with the lime as soon as it is slaked, and then throw the mortar into a pile, the entire operation not taking more than a few hours. This is a very poor way, as the lime will not slake thoroughly in such a short period, while the hot lime and steam will so char the hair as to affect materially the strength of the plaster.

26. Fine stuff is the pure lime that has been slaked to a paste in a trough by the addition of a small quantity of water, and afterwards further diluted by water until it is as thin as cream. The substance is then allowed to settle; when the excess of water appears clear, the lime held in suspension having subsided, it is drained off, and the moisture in the mass is allowed to evaporate until the stuff has become sufficiently stiff for use. If desired, a small quantity of white hair may be added to the fine stuff.

27. Plasterers' putty is practically fine stuff, but the creamy fluid having been strained through a fine sieve, the paste has been rendered much more velvety. It is always used without hair.

28. Gauged stuff consists of about three-fourths of the foregoing putty and about one-fourth of plaster of Paris. The plaster of Paris causes the mixture to set quickly, and the composition must be immediately used, no more being prepared than can be applied in 20 or 30 minutes. An excess of plaster in the mixture will cause the coat to crack. Gauged stuff is used as a finishing coat for walls and ceilings, and also for running cornices; for the latter work, equal portions of putty and plaster of Paris are used.

29. Stucco for interior work consists of two-thirds fine stuff and one-third sand. It is used as a finishing coat, the mixture being "whipped," and reduced to a thin paste by the addition of water.

30. Machine Mixing.—The advantages of machine-mixed mortar over mortar mixed by hand are that sufficient time is given for the lime to thoroughly slake, the hair and sand are added just before delivery, and the mixing is performed much more uniformly. Briefly, the process is as follows: Fresh lime is placed in revolving pans, enough water being added to slake the lime slowly. When this process is completed, the lime and water are run through screens and pumped into tanks, and allowed to remain there for about 3 weeks in order to finish slaking. When mortar is to be made, the paste is run into mixing pans, where hair and sand are added and the mass is thoroughly stirred until it is entirely homogeneous.

APPLYING THE PLASTER

31. Preliminary Examination.—Although the carpenter's specifications require that all surfaces be properly prepared for lath and plaster, and that suitable plaster grounds,

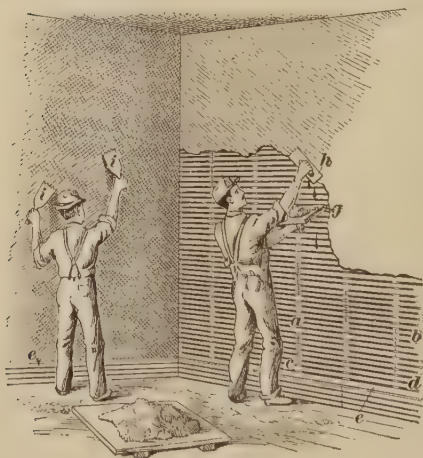


FIG. 6

such as shown at *e*, Fig. 6, be affixed to the masonry and framework for the future attachment of the finished joiner work, it is well for the plasterer to test the alinement of the walls and ceilings, or he may find that considerable "building-up" is necessary when he comes to apply the second, or

floats, coat. Where this is necessary, the lathing should be stripped off, and the surfaces brought to a plane by the use of furring strips.

In the case of dished, or concave, surfaces on stone or brick walls, the deficiency should be made good with cement

mortar before the first coat of plaster is applied. This course will insure a more durable wall, as there is little value in a mass of lime mortar unless it is applied in thin layers and thoroughly compacted.

Particular attention should be given to the spacing of the lathing. Although a simple matter in theory, in practice it will be found that unless much care has been taken in spacing the strips, many narrow insignificant slivers have been used for closers; these should be discarded and the panel stripped and relathed, otherwise much of the strength of the wall will be lost.

For three-coat work, which is the grade in general demand, the plaster grounds on brick or stone walls that are to be coated on a solid wall should be $\frac{5}{8}$ inch in thickness, and those for lathed surfaces $\frac{7}{8}$ inch. At no point should the surface of the solid wall or that of the lathing approach the face of the grounds nearer than the regulation thickness for the plaster, which will be about $\frac{5}{8}$ inch. The face of the masonry on stone or brick walls is more or less irregular, and grounds less than $\frac{5}{8}$ inch in thickness are of little value for attaching the finished woodwork.

32. Names of Coats.—Plaster is usually applied in three coats, although in some localities two is the customary number, the first coat being straightened and smoothed carefully to receive the finishing coat. This, however, is done in the cheaper kinds of plastering only. The first layer applied is called the *scratch coat*; the second, the *brown*, or *floated coat*; and the third, the *skim*, *white*, or *finishing coat*. On brickwork and stonework, and also on terra-cotta partitions, etc., the scratch coat is usually omitted.

33. Scratch Coat.—The method of applying the scratch coat is illustrated in Fig. 6. The coarse stuff is taken in batches from the *souring pile*, tempered with clean water to the proper degree of firmness, shoveled into hods, and carried to the rooms and deposited on the mortar boards, shown on the floor, ready for application by the plasterers. A quantity of mortar is placed on the wooden hand board, or hawk, *g*,

by means of the trowel *h*. Slices of the mortar are then cut from the hawk and spread firmly and evenly over the surface of the lathing or the naked wall, as the case may be. The mortar should have a dough-like consistency, should be tough and hold well together, and should be soft enough to be readily pressed in between the laths, so that it will bulge out behind and form the clinch, or key. The thickness of the layer should be fully $\frac{1}{4}$ inch, so that when set it will furnish a rigid surface to work over. In cheap work, this layer is often only a skim coat, and it is not unusual to see the rough-sawn grain of the lath protruding through the mortar. After the coat has somewhat hardened—which requires from 2 to 4 days after application—it is scratched over diagonally with wooden comb-like blades *i*; from this fact the first layer is often called the **scratch coat**. The scratches, or grooves, thus formed in the mortar fulfil the same function as the spaces between the lath—to allow a good key for the subsequent layers. The first coat should be nearly dry before putting on the next; if too dry, the surface should be slightly dampened with a sprinkler or a brush, before applying the second coat.

If the walls are partly masonry and partly wood, the first coat is applied only to the lath—unless the stone or brick walls are furred and lathed also. When the scratch coat is dry, the second coat is spread over this and the masonry. If plastering is applied directly to brick or stone, the joints in the latter should be raked out, so as to form a better clinch for the mortar. The walls should also be free from dust and be slightly dampened before putting on the mortar.

34. Brown Coat.—The second coat, which consists of fine stuff to which a little hair is sometimes added, is applied from $\frac{1}{4}$ to $\frac{3}{8}$ inch thick when the scratch coat has become sufficiently firm to resist pressure. The second layer is frequently called the **floated coat**, because its surface is worked by means of board-shaped trowels, called floats; it is also known as the **straightening coat**, since all the wall surfaces are straightened and made true by its application.

On walls, if the grounds are set true and the surfaces are not too large, the plastering can usually be brought to a true plane without much difficulty. On the ceilings, however, there is nothing to guide the plasterer, and in many cases, if great care is not taken, the ceilings have a rolling surface, as may be seen at the edges.

In order to get perfectly level walls and ceilings, especially in cases where the grounds are insufficient, resort is had to what is known as *screeding*. **Screeds** are plaster bands 5 or 6 inches in width formed on the surface to be floated. The surfaces adjacent to the angles are carefully plumbed up from the plaster grounds *e*, Fig. 7, but are kept back about $\frac{1}{8}$ inch

from the face, to allow for the finishing coat; vertical screeds *f* are formed by means of the straightedge *g*. Similar screeds *h* are formed along the ceiling angles; these screeds are made straight, and coincide with those at the opposite angles. Intermediate horizontal or vertical screeds, as *i* and *j*, are then formed between the screeds adjacent to the ceiling and the plaster

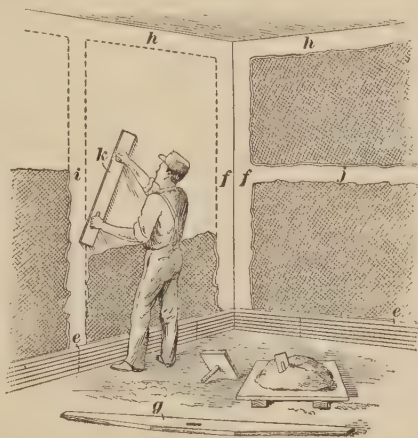


FIG. 7

grounds, as preferred by the plasterer. These are usually placed from 4 to 8 feet apart, and are gauged to line by means of the straightedge. The screeds thus form a system of framing that has been reduced to a true plane. The panels may then be filled in flush, in line with the screeds, and firmly rubbed down with the two-handed float, or derby, *k*. The surface is then worked over with a wooden hand float, the coat being firmly compacted by incessant rubbing; should the coat become dry during the process, it is moistened by applying water with a wide brush. A close, firm

layer can be obtained only by the thorough laborious operation of pressing and rubbing the particles of the mortar together; and herein lies the secret of strong, durable work—plenty of “elbow grease.” In order to form a rough base for the subsequent coat, the surface is scratched over with a broom. The ceiling surfaces are treated in a similar manner, and the screeds are carefully leveled so as to obtain true and level planes.

The space between the plaster grounds and the floor is usually finished with a scratch and a brown coat of plaster, so as to prevent air-currents from entering the room through the spaces between the furring strips. In cheap work this filling is omitted, the spaces being covered with a finished wooden base.

35. Green Work.—Very often the brown coat is put on immediately after the scratch coat without allowing time for the latter to dry; this is known as **green work**. In such a case, the first coat is made very rich, while the brown coat contains a large proportion of sand and is worked into the first so as to really form but one coat. While it saves time,

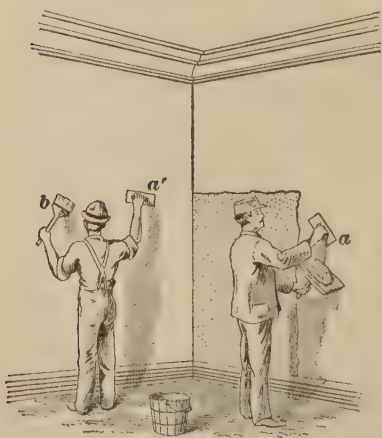


FIG. 8

this practice cannot be commended. A much better plan is to allow the scratch coat to dry before the brown coat is put on, although more labor and lime are thus required. Another objection to green work is that the excess of moisture causes the laths to swell badly, which, in drying, shrink and produce cracks in the plastering. Nearly all lime plastering is green work unless otherwise specified.

36. Finishing Coat.

Sometimes the finishing coat is omitted in cheap work, when the walls are to be papered, the brown coat being made as

smooth as possible. This method is not very good, as the rough plaster is likely to mar the smoothness of the paper.

There are several kinds of finishing coats, such as *troweled stucco*, *rough sand finish*, *hard-finish white coat*, etc.

In all cases, the material is applied to the wall in the form of a stiff paste by means of the steel trowel *a*, as shown in Fig. 8, and is spread uniformly over the surface to a thickness of about $\frac{1}{8}$ inch.

37. Troweled stucco, which consists of fine stuff and very fine white sand, to which a little white hair may be added, is thoroughly polished to a glazed finish with the trowel *a'*, Fig. 8, the surface being kept moist by water applied with the brush *b*. This is frequently called the *skim coat*.

38. Rough sand finish may be produced on the stucco by covering the hand float with a piece of carpet or felt, which will cause the sand to rise and present the characteristic sandpaper surface. It may also be made by using more and coarser sand with the lime putty.

39. Hard-finished white coat consists of gauged stuff smoothed and polished with the steel trowel. As this material sets rapidly, care should be taken to observe that the second coat is well dried; otherwise, the unequal shrinkage will cause hair cracks to occur all over the finishing coat. Marble dust is frequently mixed with the gauged stuff to give greater hardness and a surface susceptible of higher polish, about equal quantities of marble dust and plaster of Paris being used.

HARD WALL PLASTERS

40. While, by the use of the best materials and proper care in preparing and applying them, a good wall may be obtained with lime plaster, yet there are so many uncertainties about it that numerous substitutes have been brought into use, which have proved valuable and efficient. These are known under the general name of **hard wall plasters**, and may be divided into two classes: *natural-cement plasters* and *chemical*, or *patent*, *plasters*.

41. Natural cement plasters, such as *Agatite*, *Royal*, *Acme*, etc., are made from earths—found in Kansas and other states—that resemble plastic clay in appearance, and in chemical nature are similar to gypsum, from which plaster of Paris is made. They are produced by heating the natural earth to a high degree, which expels all the moisture. When mixed with water, they set like hydraulic cement, but much more slowly, thus allowing ample time for applying the mortar. These plasters have great strength and adhesive power; the full strength, however, is not attained until from 1 to 2 months after application. A sample of Agatite several weeks old showed a breaking strength of 370 pounds per square inch in tension.

These plasters work smoothly under the trowel, and adhere very firmly to wood, stone, or brick without the use of fiber or any other binding material, although such is generally used when the plaster is applied to lathing. Most of these cement plasters must be mixed with sand before using, but are prepared with and without fiber. The kind with the fiber is used for the scratch coat on lathing, and the other for the brown coat or for the first coat on brick or tile. As they are grayish in color, the finishing coat is made of lime and plaster of Paris, which is put on as before described.

In some respects, these plasters are superior to natural cement, and have been substituted for it with considerable advantage in setting fireproof tiling, etc.

42. Chemical, or patent, plasters include *Adamant*, *Windsor cement*, *Rock Wall*, *Granite*, *Rockite*, and others. While the exact composition of these plasters is unknown to the public, they appear to consist of plaster of Paris with some material added to lessen the natural rapidity of setting of that substance, so that sufficient time will be had to apply the plaster. So far as is known, the only difference in these plasters is in the materials used to render them slow setting.

Most patent plasters are sold containing sand and fiber, and only require mixing with water to be ready for use. Numerous grades are made for the different coats and

application to various surfaces. The plaster known as Adamant was the forerunner of all hard plasters, and is probably more extensively used than any other. But, while the oldest are likely to be the most reliable, all of these plasters will doubtless give good results if properly applied.

43. Keene's Cement.—When it is necessary to give walls, ceilings, etc. a hard and highly polished surface, a prepared plaster known as **Keene's cement** is generally used as a finishing coat. Strictly speaking, this is not a cement, but is made of plaster of Paris soaked in a solution of alum and then recalcined. Applied to the walls, this material becomes very hard and takes a high polish, so that surfaces finished with it may be washed without injury. Its hardness also makes it very satisfactory to use for finishing the lower portions of walls where the surface is liable to injury by contact with furniture.

44. Application of Hard Plasters.—The method of applying hard plasters differs in no essential respect from that described as green work in lime plastering. As they are more like cement than lime, the hard plasters set instead of drying. The material should be mixed fresh every hour or two, only enough water being used to give them the proper consistency. No plaster that has partially set should be remixed. When the plaster is to be applied to stone, brick, or tile, the surfaces should be sprinkled before putting on the coat. Wooden lathing should also be well moistened, so that the laths will swell before, and not after, the plaster has begun to set. The makers of hard plasters recommend that the laths be spaced $\frac{1}{4}$ inch apart and that $\frac{3}{4}$ -inch grounds be used. A better wall, however, will be obtained by using $\frac{7}{8}$ -inch grounds and a $\frac{3}{8}$ -inch key. All of these plasters, except Adamant, can be finished with a third coat of lime, putty, and sand, which should not be applied until the second coat is thoroughly dry.

When not used properly, hard plasters are inferior to lime plaster, so that the manufacturers' direction for applying them should be carefully followed.

45. Advantages of Hard Plasters.—Hard plasters have many points of superiority over lime plaster, which more than balance their extra cost and which will in time probably result in their almost exclusive use. Being machined-mixed, the plaster made from them is uniform in quality and strength and has unvarying proportions of the constituents, while two batches of lime plaster may differ a great deal in this respect. They are also much harder and more tenacious, and resist fire and water better than lime, and the small quantity of water used in mixing enables them to dry much more rapidly. They are not injured by frost after they have begun to set, but should be protected from it for the first 36 hours after being put on the walls. Heat and moisture are not readily transmitted by hard plasters, and being more dense than lime plaster, they do not absorb noxious gases nor permit the entrance of disease germs.

ORNAMENTAL PLASTERING

46. Cornices.—As a rule, cornices are molded before the finishing coat is put on, the operation of making them being about as follows: Longitudinal strips are first attached to the wall, as at *b, b*, Fig. 9, on which a templet guide shown at *a* is run. Sometimes a strip is also attached to the ceiling, but more often the ceiling guide is merely a line. The coarse stuff is made to conform to the approximate profile with a *muffled templet*, that is, by forming a layer of plaster of Paris about $\frac{1}{8}$ inch in thickness along the edge of the templet; or an extended profile can be cut out of zinc and temporarily attached to the correct templet. The templet is placed in position and pushed along the angle of the wall, as indicated in Fig. 9. When the coarse stuff has been correctly profiled, the surface is coated with gauged stuff and carefully worked over with the correct templet until an exact and perfect finish is obtained. The internal and external angles cannot be finished by means of the templets, but must be carefully molded and mitered by hand, using jointing tools, such as shown in Fig. 5. Some plasterers prefer to push the

templet with the left hand instead of with the right, as shown in the figure, so that they can handle the trowel with the

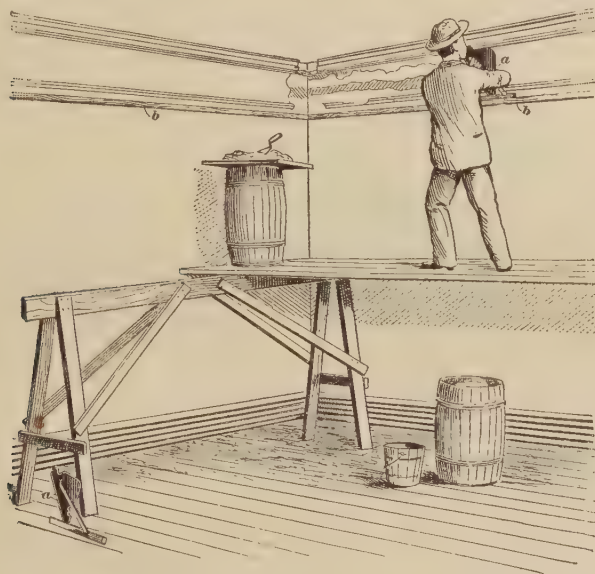


FIG 9

right hand when applying the stuff and make up any deficiency; therefore, the templets should be made to suit the direction in which they are intended to be driven.

47. Sometimes the clinch, or key, is reinforced and the plaster held more firmly in place by using projecting spikes or large nails, which are driven into the wall or ceiling before the mortar is applied.

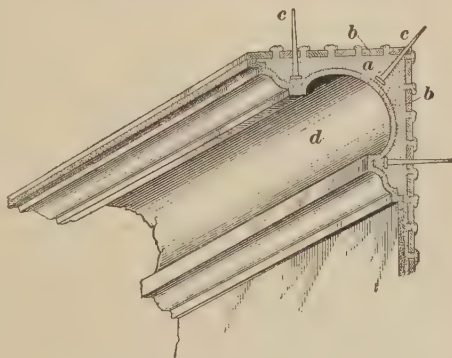


FIG 10

This method is shown in Fig. 10, in which *a* shows the mortar; *b, b*, the laths; *c, c*, the spikes; and *d*, the finished surface.

When the cornice projects considerably, the angle should be blocked, or cradled, and lathed, to reduce the quantity of plaster required, as there should be no thickness of plaster much over 2 inches. This method is represented in Fig. 11,

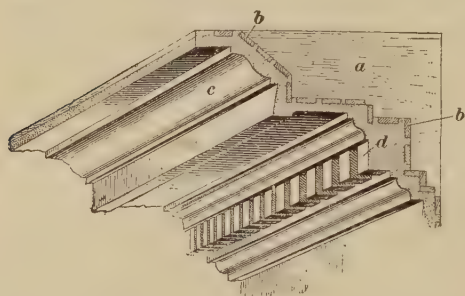


FIG. 11

in which *a* shows one of the blocks, which are nailed to the floor joists; *b, b*, the laths; *c*, the cornice; and *d*, a dentil course. If the cornice is to be ornamented as at *d*, a recess is left in the plastering to receive the pieces to be

inserted, which are formed separately and then stuck in place by liquid plaster.

When there is much ornament, it is cheaper to cast the cornice of plaster of Paris in sections 2 feet or more long; these may be attached to the wall by thin plaster. Careful work is required to make the molded pieces come together or match properly.

48. Centerpieces.—Centerpieces that consist only of plain circular moldings are formed in the same manner as cornices, except that the mold, or templet, is so fastened as to swing around the center of the ornament.

When decorated centerpieces are used, they are usually cast in a mold and stuck on the ceilings by liquid plaster of Paris. Nearly all kinds of ornamental plastering, such as paneled ceilings, bas-reliefs, imitations of foliage, etc., may be easily cast of plaster of Paris and made to serve the purpose as well as more costly decorations.

PLASTER ORNAMENTS AND SCAGLIÓLA

49. Plaster ornaments are now less extensively used than formerly. They are usually made of plaster of Paris and lime, but for cast work, only the former is used.

A light and strong material used to some extent for ornamental work is made by applying a thin layer of plaster of Paris to pieces of stretched canvas, forming a kind of board. If casts are to be made, the plaster is poured into the molds, and while it is still soft, the canvas backing is pressed lightly into it.

Another material, known as *carton pierre* and by various other names, is also much used for ornamental work. It is composed of whiting (ground chalk), paper pulp, hemp fiber, etc. mixed with glue, which is pressed into molds, backed with strong paper, and dried. Ornaments made of this substance are much tougher and lighter than if cast in plaster of Paris, and are considerably used for interior decorations and also for outside work; for the latter use they should be painted.

50. *Scaglióla* is a material applied to columns, walls, etc. to imitate marble. The first, or ground, coat consists of lime mortar having a large proportion of hair mixed with it. This mortar is applied in the usual way and allowed to become thoroughly dry. Another coat is then applied, composed of Keene's cement, or plaster of Paris mixed with glue, or gelatine, to make it more dense and compact, and to retard the setting. Various coloring matters are also added to produce the required effect. The second coat is sometimes put on with a brush, a great many applications being necessary to properly blend the colors. To impart to the work the requisite polish, similar to marble, the workman rubs the surface, when it is hard, with pumice stone, then polishes it successively with tripoli, pulverized charcoal, and a piece of soft cloth, and finishes with oil. When well made and polished, *scaglióla* can hardly be distinguished from marble. It is unsuitable for exterior decoration, but

for interior work is nearly as durable as good stone, and in Europe there are columns made of it that are hundreds of years old.

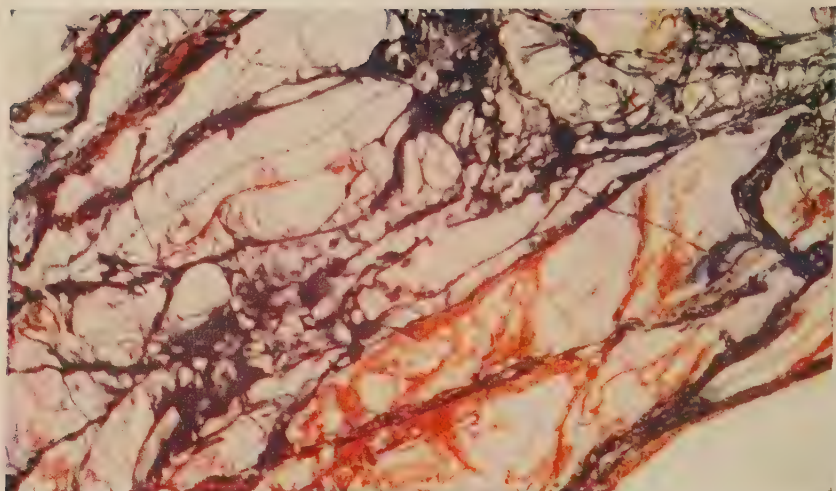
51. Artificial Marble.—There is now on the market an artificial marble composed principally of Keene's cement. This marble can be made very strong, and has the advantage over natural marble in that it is lighter and can be obtained in larger pieces without any wax filling. It can be used for columns, balustrades, wainscoting, store counters, bathroom finish, and innumerable other purposes. This artificial marble is made into slabs, columns, or any desired shape, and is cemented into place by Keene's cement.

The most beautiful marble and onyx can be very closely imitated at a reasonable cost. Fig. 12 illustrates some styles, or colors, of artificial marble made by the American Art Marble Company, of Philadelphia. At (*a*) is shown pavonazza; at (*b*), red Numidian; at (*c*), dark sienna; and at (*d*), Alps green.

A very durable imitation of marble is also made from glass. This material is stronger and more dense than marble itself, and is useful around toilet rooms and places where cleanliness is to be desired. On account of its non-porous surface, it is particularly suitable for sanitary use. It may be had in various colors, although usually made pure white.

STUCCO

52. The term **stucco** was first used by the early Italian artificers to define a superior grade of plaster compounded by them; and their skilful manipulation of the material has never been excelled. From the fact that by using stucco the appearance of dignity and stateliness on an otherwise mean and poverty-stricken structure could be acquired at a very low cost, it was for many centuries very extensively used. Many of the so-called stone and marble palaces will be found, on examination, to be only brick shells coated or veneered with stucco, but so well treated and handled as to



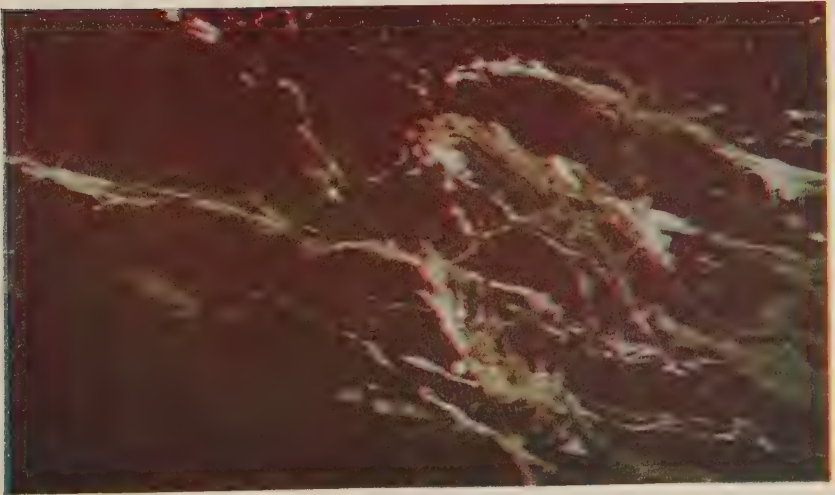
(a)



(c)



(b)



(d)

present a very superior surface, being scarcely discernible from the material that it is made to imitate. At the present time, stucco is used only to a limited extent and only for a cheap class of structures.

To secure the best results in stucco work, a good cement mortar is requisite, as lime mortar, which was formerly used, does not prove very durable. For use on brickwork, the plaster should be made of Portland cement and clean sharp sand mixed in the proportion of one part of cement to three parts of sand, with sufficient water to make a stiff paste. Before adding the water, the mortar joints in the brickwork should be raked out, so as to form a good clinch for the covering, and the surface of the wall should be well dampened to prevent the bricks from too quickly absorbing the water in the mortar. Resort is sometimes had to screeding, to make the surface true and uniform. When the mortar is put on in more than one layer, the previously laid coat should not be allowed to dry before the next one is applied, as the coats will not adhere well and will probably scale off. Before the finishing coat has hardened, it may be marked with lines to indicate the joints in ashlar. The mortar may be colored to represent stone by the use of mineral colors, such as Venetian red or the ochers; while if a light color is desired, it may be obtained by mixing a small quantity of lime with the cement.

53. Rough cast is a kind of coarse plastering that is considerably used in Canada and other places with cold climates as a substitute for siding and shingles. It costs less, is more durable and much warmer than wood, and resists fire to a considerable extent. If a frame building is to be covered, it should first be stiffened by having the partitions built and the outside sheathing put on. Laths are then nailed on the sheathing, being laid diagonally and about $1\frac{1}{2}$ inches apart, breaking joints about every 18 inches. Over this course is laid another, the laths sloping in the opposite direction, with similar spacing and broken joints. This thickness of laths should be put on with great care, to

insure the permanence of the work. If wire or expanded-metal lathing is used, there will be considerable gain in strength and fireproof qualities.

The scratch coat should be made of rich lime mortar having a large proportion of hair, and should be mixed about 4 days before it is applied. This coat should be thoroughly laid on and well pressed between the laths in order to form a good clinch, and its surface should be well scratched so as to form a key for the second coat. It should be allowed to dry thoroughly, but its surface should be sprinkled before applying the second coat, which has the same composition as the first. The second layer should be kept moist and soft until the finishing coat is put on. The latter is called the **dash**, and is made of clean fine gravel and lime stirred up with water until the mass has a semifluid consistency. Various coloring matters may be added if required. A black mortar may be obtained by mixing 5 pounds of lampblack with the dash; a buff, by using a like weight of copperas. The dash is then thrown on the plastered walls with a wooden float about 5 or 6 inches square. Before the dash dries, it is gone over with a brush dipped in the liquid, to give the face a uniform appearance.

For 100 square yards applied as described, there will be needed 1,800 laths, 16 pounds of $1\frac{1}{4}$ -inch lath nails, 12 bushels of lime, $1\frac{1}{2}$ barrels of hair, $1\frac{3}{4}$ cubic yards of sand, and $\frac{3}{4}$ cubic yard of washed gravel. For the dash, a quarter barrel of lime putty should be mixed with every barrel of washed gravel.

54. Staff.—Although staff has been used for a long period in Europe, it was first brought into extensive use in the United States in 1891-93, when it was employed for constructing the World's Fair buildings at Chicago. As used at Chicago, it is made about as follows: The ingredients are plaster of Paris, water, and hemp fiber, the latter being used to bind and strengthen the cast. A suitable mold having been made, the hemp is cut into 6- or 8-inch lengths, bunched loosely, dipped in the liquid, and placed in the mold in layers until the mold is full, each handful being interwoven with

those previously laid and pressed in so that the cast will be compact and uniform throughout. When the mold is filled, the surface is smoothed over by hand, and when thoroughly set, the cast is removed. In warm weather, about 36 hours is necessary for thorough drying, but in cold weather, more time is required and the cast should not be subjected to frost before it is dry.

Staff may be nailed directly to the rough boarding of a wooden building. If it is to be applied to a new brick structure, however, furring strips should be inserted in the brickwork.

This material, while cheap and satisfactory for temporary structures, does not seem well adapted for permanent buildings, as it deteriorates in course of time in the Northern States owing to the rapid changes of temperature. Where the temperature is more uniform, staff has proved to be a very durable material.

WHITEWASHING

55. Whitewashing being often included in the plasterer's specifications, a brief mention of it is desirable. Common whitewash is made by slaking fresh lime and adding enough water to make a thin paste. It is applied to walls and other surfaces with a brush. Whitewash will adhere best to rough and porous surfaces. For good work, two coats should be put on. By using 2 pounds of sulphate of zinc and 1 pound of salt to each $\frac{1}{2}$ bushel of lime, the whitewash will be rendered much harder and will be prevented from cracking. Its durability, especially for outside work, may be increased by mixing 1 pint of linseed oil with each 2 gallons of whitewash.

Whitewash is a very useful agent for preventing decay of wood, and is valuable from a sanitary point of view in buildings of wood, stone, or brick.

INSPECTION OF WORK

56. Lathing.—Before the lathing is begun, the inspector should see that the furring and grounds are properly placed and are plumb and square; also, that the angles of chimneys and other projections are right angles. If the lathing is of wood, he should see that the laths are free from bark and loose knots, and that they are put on with proper spacing, well nailed, with no springy ends, and end joints broken at least every 18 inches. Over door and window openings, the laths should extend to the next stud on either side of the frame. As far as possible, the lathing should run the same way, as cracks are liable to occur in the plastering at places where the direction of the lathing is changed. The junction of brick and wooden walls, as well as lintels and unfurred timbers, should be covered with pieces of metal lath, as already mentioned.

57. Plastering.—If lime plaster is to be used, the inspector should see that the lime is fresh and without unburned lumps, and should allow none to be used that has begun to slake. The sand used should be sharp and free from earthy matter. The hair should not be added until the lime has become thoroughly slaked and cooled, and the mortar should be made at least a week before use. It is well to become acquainted with the appearance of good mortar, so as to be able to judge its quality.

Before beginning to plaster, the openings in the building should be closed with boards or muslin. In winter, a building in which plastering is to be done must be heated. Lime mortar, especially, is rendered worthless if frozen and then thawed; hard plasters, also, should not be permitted to freeze. The inspector should see that the first coat is well clinched between the laths, and is thoroughly dry before the second coat is put on. If the scratch coat is to be laid on brick, the walls should be well wetted before applying the mortar. Special care should be taken with the brown coat, as the appearance of the finished work depends to a great

extent on good workmanship in applying this coat. Its surfaces should be plane, with straight and square angles and a level ceiling. If hard plasters are used, the directions furnished by the makers in regard to mixing sand, etc. (if not obtained already mixed) should be carefully followed. Plaster that has partially set before use should be rejected.

MEASUREMENT OF WORK

58. Lathing is figured by the square yard and is usually included with the plastering, although in rural districts the laths are often put on by the carpenter. Plain plastering, such as that on walls and ceilings, is always measured by the square yard. Provision in regard to deduction for openings should be made in the contract, for unless this is agreed on, the custom of the locality will govern. In some parts of the country, one-half the area of openings is deducted; and elsewhere, no allowance at all is made for openings unless they are very large.

Where the work is difficult to put on, or where there are many angles, as in closets, the under side of stairs, etc., the price per yard is usually more than for broad unbroken surfaces. This is also the case when staging is required, and when the surfaces are other than plane. Ornamental work, of course, costs much more than plain; cornices, moldings, etc. are usually measured by the lineal foot, with extra allowance for corners.

TILING

59. The method of manufacturing tiles for floors, wainscots, etc. is similar to that employed for making terra cotta, but as these uses of tiles are in the nature of finishing processes, analogous to plastering on walls, the subject is considered in this Section.

60. Tiles are used very extensively for flooring aisles and passages in churches and office buildings, the floors of waiting rooms in railway stations, and also for vestibules, bathroom floors, hearths, borders, and backs of fireplaces in dwellings. Very artistic effects may be produced by the use of different colors and shapes; and for wainscots, by the use of the great variety of plain and decorated tiles. Tiles are of every color, and are made as large as 6 inches square, but it is not recommended that pieces of this size be used for flooring, as they are likely to break or become loose unless very carefully laid.

61. The art of laying mosaic floors was known to the Romans, by whom the component parts were termed *tesseræ*, from the word meaning *tesselated*, or checkered. These consisted of small pieces of hard material of various colors bedded one by one in a layer of cement, each piece being leveled with the others; and on the completion of the work any irregularities were corrected by rubbing the whole to a plane surface.

The modern tile floor is composed of pieces cut by dies. The pieces are thus uniform in size and fit closely together, having an almost imperceptible joint. As a guide in setting, a colored drawing of the intended design is usually made. The full-sized pattern is laid out on a perfectly level cement floor, on which the *tesseræ* are placed, face downwards, the workmen being guided in the arrangement of colors, etc. by the drawing. The pieces are afterwards joined together

by a layer of cement applied to the back, or upper surface, and in this way they can be formed into slabs of convenient size, which, when the cement has hardened, are ready for use, and can be easily laid either as centerpieces, borders, or pavements.

62. Tiles may be laid directly on the concrete of fire-proof floors. When the floor is framed with wooden beams, however, the foundation course should be of bricks set edge-wise on short pieces of boards that are laid on strips nailed to the sides of the beams. In order to save material, the bricks are sometimes laid flat. The average thickness of the tiles is $\frac{1}{2}$ inch, although they often run $\frac{5}{8}$ inch, so that the top of the layer of bricks should be $\frac{3}{4}$ inch below the finished floor. The tops of the beams should stand in the same relation to the tiling that they would to the top of a wooden floor, in order to avoid differences in level at the junction of the wooden and tile floors. In the case of a single wooden floor, the distance will be usually $\frac{7}{8}$ inch, and in a double floor, $1\frac{3}{4}$ inches.

After the bricks are laid, the brick surface should be swept clean and then well dampened. The tiles should also be soaked in water for some time before they are used. If this precaution is not taken, the bricks or tiles will absorb water from the thin layer of cement between them and make it powdery and useless. Only the best Portland cement should be used. The cement should be mixed rather thin and without sand.

63. When the tiles are laid with a centerpiece, the pattern should be commenced at the center, the position of which should be accurately ascertained by previous measurement. Straightedged strips of board should be put down as guides for each day's work, not only for regulating the lines of the pattern, but also for securing a uniform surface. This is done by first setting the strips carefully, and then laying the tiles by the aid of a straightedge resting on the strips. Each tile is set on a bed of cement spread for it, and beaten down to the proper level with the wooden handle of a

trowel. When a sufficient number of tiles has been laid, the joints may be grouted with liquid cement, which should, however, be immediately wiped off the surface of the tiles, since it is difficult to remove when dry.

If the cement used is good, the tiles cannot, after a few days, be removed without breaking, so that too much care cannot be exercised in placing them properly at first. When the pattern reaches the edges, it is usually necessary to cut many of the tiles. This can be done by soaking them well in water, and then scoring a line with a sharp chisel, where the separation is to be made; by placing the chisel exactly on the line, a sharp blow will effect the separation. Wide chisels should be used, and the tiles must be well soaked, for unless this is done they are likely to fly into fragments.

After the tiles are laid, the floor is covered with sawdust an inch or so deep, and planks are then laid over this, to protect the tiling until it has become set. If a baseboard or a wainscot, whether of wood or stone, is required, it is then fitted down on the tiling.

64. If marble tiles are used in place of terra cotta, the laying should be done in the same way, that is, on bricks set on edge. The marble tiles are considerably thicker than the clay tiles, being generally from $\frac{7}{8}$ to $1\frac{1}{4}$ inches, and the guide strips should be set accordingly. The under side of the marble is usually quite rough; therefore, the laying is easier than that of clay tiles. Mortar made of equal parts of cement, lime, and sand may be used.

65. Fig. 13 is an example of a bathroom or lavatory wall faced with white tiling. A dado, or wainscoting, is emphasized half way up the wall by the insertion of a course of colored ornamental tiling, done in gold and capped with a band mold. At the floor, a special plinth, or base, course is inserted. An ornamental frieze is put in near the ceiling line immediately under the angle cove, and makes a suitable and effective framing for this apartment. Specially designed tiles form the door frame, and can be selected from manufacturers' catalogs. It will be noticed that special curved



(b)



(22)





(d)



(c)











a,

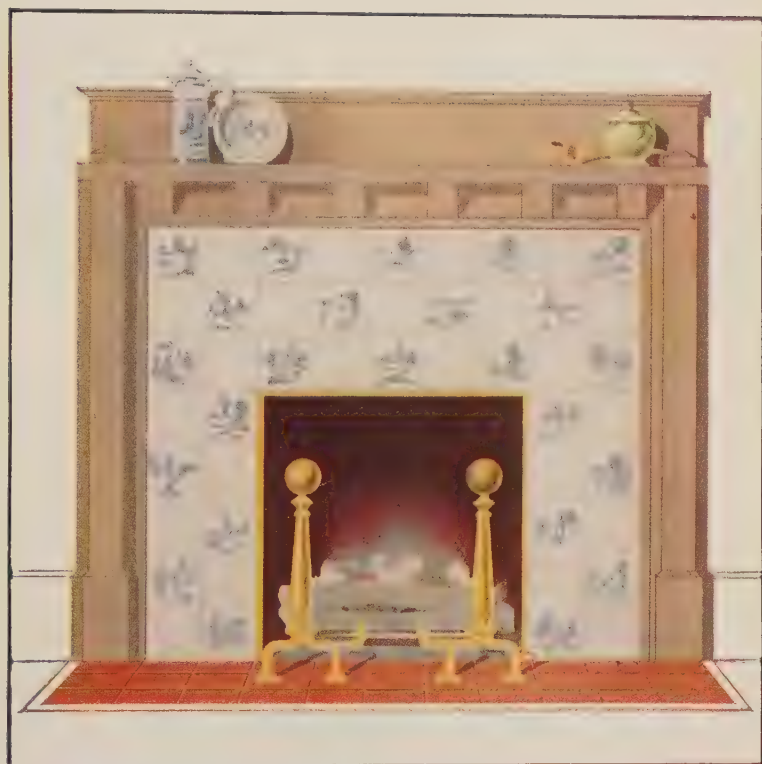


b,



(c)

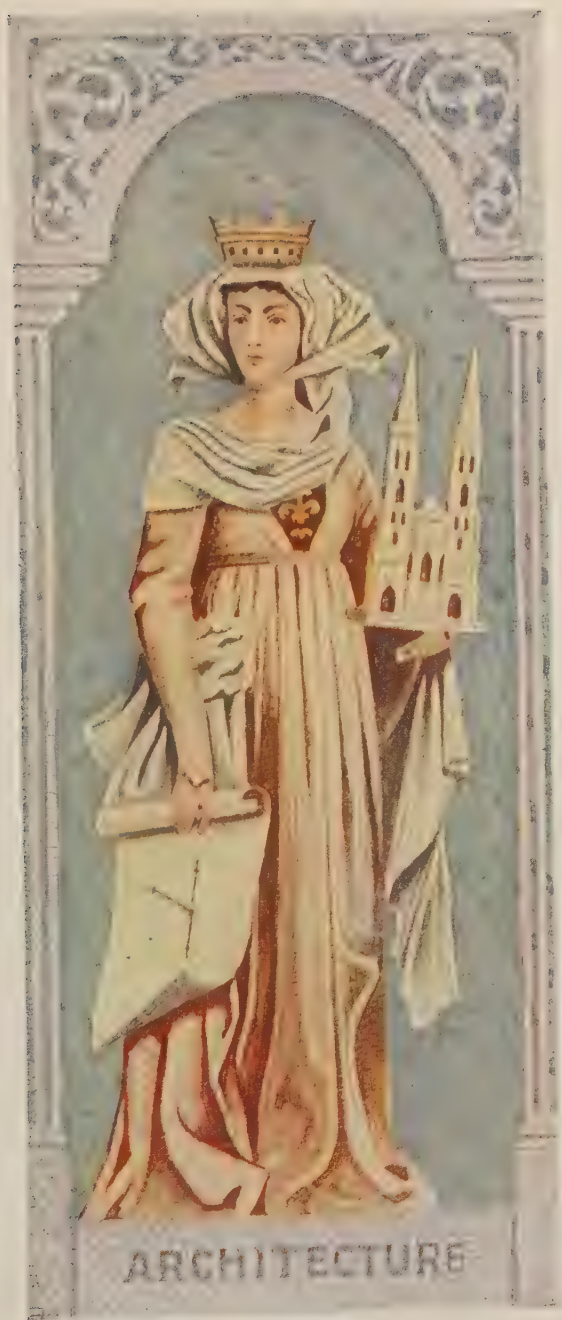




ILL. 30C \$58

FIG. 19





tiles are used at the junction of the floor with the wall and also between the wall and the ceiling. The purpose of these curved tiles is to do away with angles where dust and dirt may accumulate and which are hard to keep clean.

The designer in laying out such work must remember that it is always cheaper to select stock tiles than to have them made special. He will also find that he will be able to get tiles kept in stock at much shorter notice than those that have to be made especially for one job.

This design possesses the charm of cleanliness, and makes the room bright and attractive. While the general constructive features shown in Fig. 13 should be observed in all rooms of this character, sufficient distinction can be obtained by the selection of appropriate ornamental designs. Without decoration, a tiled wall of this kind makes an excellent and sanitary finish for walls and ceilings in surgical wards of hospitals.

66. The four floor designs shown in Fig. 14 well illustrate the scope of this material and the elasticity possible in design. The tiles in two of these examples are square, and in the others they are hexagonal. The nature of these units, if uncut, compels conventional designs. At (*a*) is shown a design with a rich all-over pattern for the field, and an interlaced circle with emphasized center for the border. At (*b*) is shown a design where the center is much more open in treatment, and the border is a simple meander. The color scheme in this pattern is much more quiet than that of (*a*). The fields in (*c*) and (*d*) are much more open in treatment than in (*a*) and (*b*), and the borders are more prominent. With a number of different colors, the design and color schemes possible with these tiles are almost infinite. It will be noticed that while (*a*) and (*b*) are made of square tiles, (*c*) and (*d*) are laid with tiles having six sides.

67. Figs. 15 and 16 are examples of much more elaborate designs where tiles of irregular shape are necessary in order to carry out portions of the design, as, for example, in the beaks of the peacocks, the leaves of the flowers in the border,

etc. Fig. 15 would be suitable for a vestibule floor at the base of a flight of stairs, where a good view of the design would be obtained by persons descending. Fig. 16 also illustrates the elasticity of use of these tiles and the possibilities in color. This design was used for a room in a private residence where its setting was treated with corresponding richness.

68. In Fig. 17 will be seen an illustration of the possibilities of tile work in connection with a fireplace. It will be noted that the backgrounds and ornamental parts of the various designs are composed of tiles of irregular shapes, while the borders are rectangular in shape. The part shown at (*a*) represents a panel over the mantel shelf, (*b*) shows the panels about the fireplace opening, and (*c*) is the hearth.

69. Completed fireplaces with the tile in place are shown in Figs. 18 and 19. The former shows the effectiveness of a tile of plain color without ornament, relieved only by the brass hood, angles, and lamp. Fig. 19 shows a very quaint and simple wooden mantel painted a mouse gray with Dutch blue tiles surrounding the fireplace opening, which is trimmed with a brass angle and set off with andirons to match. The hearth is in red-brick tiles.

70. Fig. 20 shows two panels of a class similar to Fig. 17. They are quiet and dignified in color, and were used in the vestibule of a church.

71. Fig. 21 illustrates the possibilities of this material when applied to the delineation of drapery and the human figure. This work is very costly and is used only in the most expensive buildings.

LIGHTING FIXTURES

HISTORY OF ILLUMINATION

PRIMITIVE ILLUMINATION AND DEVELOPMENT

1. The methods and agencies of illumination are various, and have changed and improved with the progress of time. The earliest known method of obtaining artificial light was that used by primeval man, and was obtained from what is now called a bonfire, which was produced by means of sparks generated by the friction between two rapidly revolving pieces of dry wood, the sparks being nursed and fed into flame.

It is not supposed that these fires were transported from place to place, but undoubtedly our ancestors carried fagots, lighted at these fires, to dispel the surrounding darkness or to light other bonfires, thereby establishing a system of artificial illumination by torches. As mankind grew older and civilization advanced, the wooden torch gave place to the rush candle or rushlight.

The rush is a grass-like herb having a long soft stem; this stem was first peeled to the pith, except one strand (which was left to hold the pith together), and then soaked with the fat of animals or dipped into fish oil. With this light originated the first ornamental and essential appliance for holding or supporting the means of illumination: a notched stick supported on a wooden base.

The next step was the substitution of woven-cotton strands, or wicks, for the rush stem, and the burning of animal fats, pitch, and wax at the end of these woven-cotton wick

ends in open metal or earthenware vessels, as shown in Fig. 1, the illuminant being drawn through the wick to the flame by capillary attraction. This is the prototype of the lamps as now known. With this new method of illumination, it became incumbent on the maker to evolve some method of abating the noxious smoke and disagreeable odors attending the burning of these primitive lamps and to increase the field of illumination, which was very limited on account of the closeness of the flame to the body of the lamp.

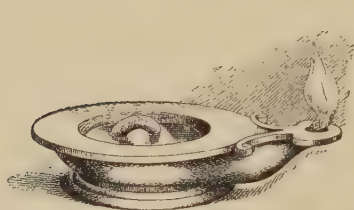


FIG. 1

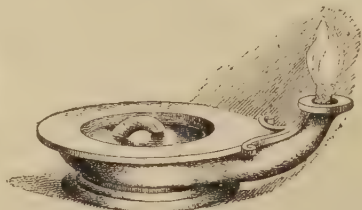


FIG. 2

The first of these imperfections was partly remedied by distilling oil from animal fats and then adding rich perfumes to the product, thus causing the oil to burn with less resulting soot and with the odors disguised by the perfumes. The other imperfection of the primitive lamp was gradually obviated by raising the wick end, as shown in Fig. 2. The number of lights was often increased to two or three, and a cover was placed over the reservoir with a small hole left in the top for filling.

2. The Candle.—The candle was also used at a very early period, though probably not as early as the lamp. In the candle, the mass of wax, stearin, or paraffin takes the place of the animal fat or fish oil of the rushlight and the reservoir of oil in the lamp, and gives the distinctive name to the different kinds of candles. In later years, the candle, because of its cleanliness, great practical adaptability and freedom from odor during combustion, became the chief source of light in the homes of the well to do.

3. The Kerosene or Modern Lamp.—The type of lamp shown in Figs. 1 and 2 was used in an improved form

up to the end of the 18th century, when rapid improvements began to be made and continued throughout the 19th century, resulting in the kerosene lamp of the present day.

Kerosene, which is a product of petroleum, is burned at the wick end in receptacles manufactured for that purpose, having the flame protected from draft by a glass chimney, which rests on a perforated base through which air is supplied beneath the flame to aid combustion. The wick has changed from the solid-rope form of the primitive lamp to the flat-ribbon or hollow-cylinder forms, and the light is reflected down or about the lamp, or both, by suitable shades or reflectors.

4. Gas and Electricity.—Next in order in the development of lighting came illuminating gas, and later electricity, both within the 19th century. These two are the methods of illuminating now most generally used and the appliances here considered are those used in connection with them.

ILLUMINATING APPLIANCES

GAS AND ELECTRIC FIXTURES

INTRODUCTION

5. The appliances employed for lighting buildings with gas and electricity may be divided into five groups; namely, *brackets, pendants, lanterns, chandeliers, and standards*. They are usually specified in the gas-fitting or electric-lighting specifications and are furnished and fitted by the gas-fitter or electrician. Frequently, however, the owner of a proposed building selects the fixtures, and then it is customary for the architect to state in the specifications that the fixtures will be furnished by the owner and placed by the gas-fitter or electrician. This plan gives the owner an opportunity to see his building finished, grasp the treatment of the interior finish, and then, with the advise of the architect, intelligently

select designs appropriate for and in harmony with the finished structure. Gas and electric fixtures are purchased from manufacturers or supply houses, and are never made by gas-fitters or electricians—who simply fit and place them.

Fixtures to match the interior decorations, trim, etc. are sometimes especially designed, and as the factories are generally located at a considerable distance from the work being erected, it is well for the designer to have some knowledge of the methods of manufacture and construction of gas and electric fixtures, otherwise his drawings, although beautiful in design, may not be practical. Manufacturers are very often compelled to change designs slightly so that the fixtures can be built within reasonable cost. If a designer knows what can and what cannot be made, and draws his fixture designs accordingly, he will be able to incorporate the proper treatment in the design without any danger of the design being altered and mutilated at the factory.

6. Fixture Terms.—A fixture that is made for gaslight only is called a **gas fixture**, or a **straight-gas fixture**, which means that there is no electric lamp or wiring in connection with it.

A fixture that is made for electric light only is called a **straight-electric fixture**.

A fixture that is made for both gaslight and electric light is called a **combination fixture**, or a **gas-electric fixture**.

BRACKETS

7. Stiff Brackets for Gas.—A **bracket** is a fixed or movable arm attached to a vertical surface and can provide illumination from one or more points; in the latter instance, several arms to support the different points of illumination are placed on one body. The component parts of a gas bracket, shown in Fig. 3, are as follows: The *bracket back* is at *a* and is usually a spun metal shell to cover the hole around the gas outlet on the wall. In designing this part, a careful designer will take into consideration any rough or

unsightly space around a gas outlet and arrange the size accordingly. The *stiff joint* is at *b* and is made of either bar metal or cast metal; it is drilled and tapped to fit the gas outlet and cock. The *cock* is at *c* and is fitted with a key that serves to regulate the flow of gas to the tip. The *arm* is at *d*, and is made of iron pipe, as at *h*; it screws into the cock fitting and into a tapped socket of the end fitting *e*. The iron-pipe arm is usually covered with a brass tubing *d*. The *end fitting* *e* of the arm is generally in the form

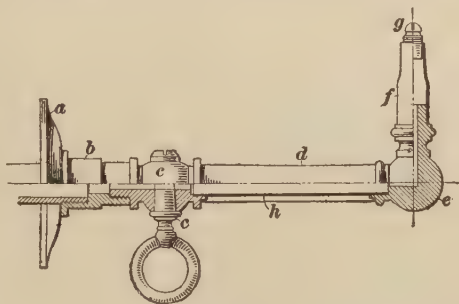


FIG. 3

of an elbow, as shown, and changes the flow of gas from the horizontal to the vertical direction. The *pillar* *f* and the end fitting are always made of brass tapped $\frac{3}{8}$ inch, and the *tip* *g* surmounting the pillar is made of fire-hardened clay, being commercially called a *lava tip*.

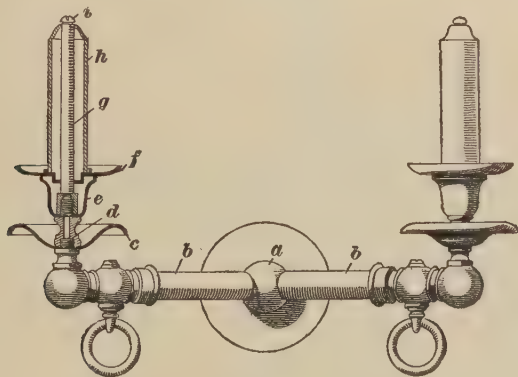


FIG. 4

8. In Fig. 4 is shown a **two-light bracket** with two cocks and with pillars of porcelain formed to imitate candles. The parts of this bracket may be described as follows: The *body* *a* is turned of bar metal, or is a metal casting, and is

tapped in the center at the back to fit the stiff joint and at the two points in front for the arms. The *arms*, as shown at *b*, are usually of brass or bronze tubing, which is as practical for gasways or arms as iron pipe. The cock employed in the construction is termed an **L** *cock*, being combined in this

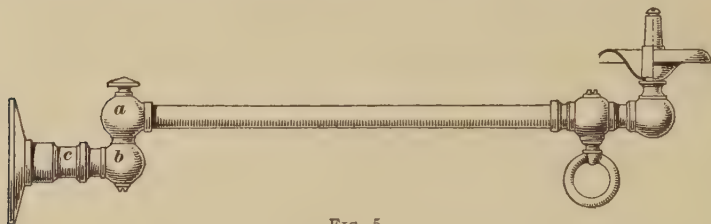


FIG. 5

instance with the end fitting. The *pan* *c* surmounting the end fitting is of spun-shell or cast metal. The *neck* *d* is of brass tapped $\frac{3}{8}$ inch and is screwed to the end fitting, thus serving to hold the pan in position. The *candle socket* *e* is of spun metal shell or is a metal casting, and is held in position by the *candle tube* *g*. The *glass bobeche* *f* is passed down

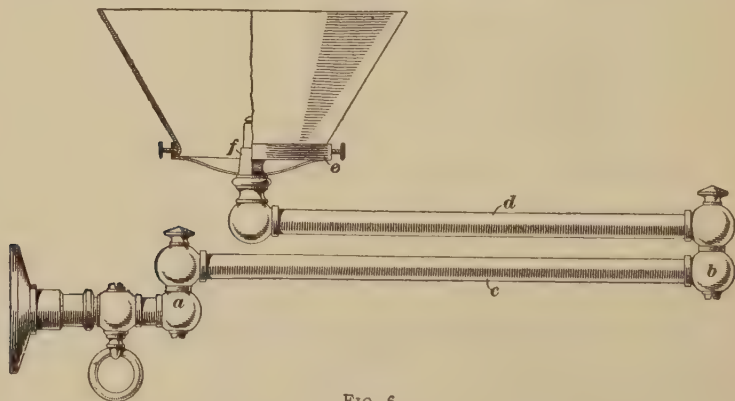


FIG. 6

over the candle tube *g* and rests on the candle socket *e*. The candle tube *g* is made of brass pipe tapped $\frac{3}{8}$ inch and is screwed to the neck *d*, thus holding in position the candle socket *e*, the glass bobeche *f*, the porcelain candle *h*, and the tip *i*.

9. Movable, or Swing, Brackets.—The movable, or swing, bracket is similar in construction to the stiff brackets, with the exception that a swing bracket includes a turned metal swing fitting at the end of the stiff joint *c*, which allows the bracket arm to swing freely in a horizontal direction. This fitting is shown at *a b*, Fig. 5.

As shown in Fig. 6, **double-swing brackets** combine two turned metal swing fittings in construction—one at the swing joint *a* and one at the end *b* of the lower arm *c*. The top, or upper, arm *d* is made 2 inches shorter than the lower arm, and is fitted with a globe holder *e*, which is held in position by the pillar *f*.

10. Brackets for One Electric Light.—As the current for electric lights is supplied through wires, an opportunity is given for greater freedom in designing fixtures than is possible where gas is used. Electric-light brackets similar to the one shown in Fig. 7 are only adapted to illumination where the connection with the wires is made through wooden walls. In the figure, the *bracket back a* is fastened to the wooden blocking by three screws and it acts as a tripod in serving to hold the bracket in place. This bracket back is made of cast metal, and must be of sufficient depth to permit the necessary connections to be made. The *arm b*, which is made of metal tubing not less than $\frac{3}{8}$ inch in diameter, is fitted to the bracket back and capped with a $\frac{3}{8}$ -inch brass *end fitting c*; this fitting supports the *socket d*, and the incandescent lamp *e*.

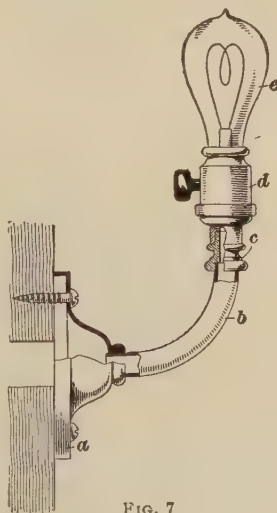


FIG. 7

In Fig. 8 is shown a bracket that is to be connected with the wires through a junction box in the wall, but not shown in the illustration. Junction boxes are used for the purpose of having proper insulation at the outlet, and if properly

installed they prevent the contact of the wires with the steel or iron used in buildings. In the event of contact, the current would become either grounded or short-circuited if the junction box and insulating joint were not used.

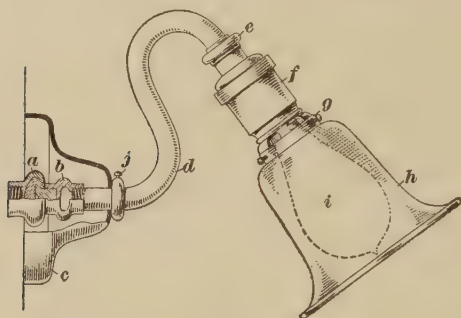


FIG. 8

The component parts of an ordinary electric bracket like that shown in Fig. 8 are: insulating joint *a*, hickey *b*, bracket back or canopy *c*, arm *d*, end fitting *e*, socket *f*, shade holder *g*,

shade *h*, and lamp *i*, shown by dotted lines.

The *insulating joint*, which is shown in detail in Fig. 9, is a cast-iron coupling that connects with the junction box and serves to insulate the fixture from the iron work of the building, so that the effects of a short circuit in the fixture will not be communicated to the building. In the interior of the insulating joint is a bed of mica, or isinglass *a*, which is an

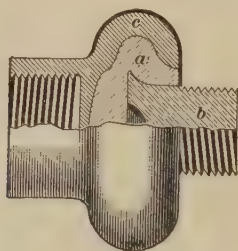


FIG. 9

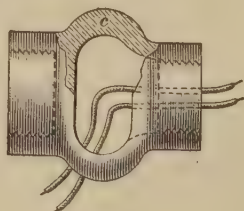


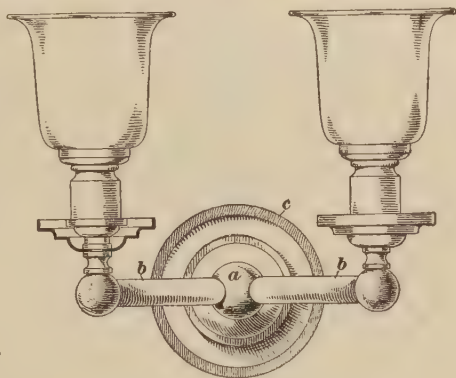
FIG. 10

insulating material and also serves to hold the nipple *b* in position. The hickey *b*, Fig. 8, is connected with the insulating joint by a screwed joint. The middle globular part of the insulating joint is covered with a thickness of vulcanized rubber, as shown at *c*, Fig. 9.

The *hickey*, which is made of cast iron, acts as a coupling in connecting the arm with the insulating joint, and, as

shown in Fig. 10, is somewhat similar in shape to the insulating joint. It is provided with holes on the side of the middle part through which the wires for connection are passed, and prevents the wires from being bared, or abraded, while being fished through, thereby eliminating the possibility of grounding or short-circuiting the current.

As shown in Fig. 8, the *bracket* is furnished with a sliding back *c*, which can be placed anywhere on the arm of the bracket necessary to give freedom in making connections at the wall, after which it is brought against the wall and secured in place by a setscrew *j*, Fig. 8.



11. Brackets for Two or More Electric Lights.—In conjunction with the other essential parts, the brackets for two or more electric lights are practically the same as those used for one light, and are formed by a combination of a body *a* and arms *b, b*, as shown in Fig. 11. In

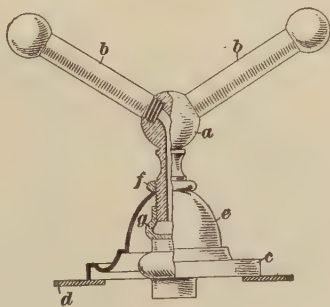


FIG. 11

connecting brackets, when the bracket back *c* comes in contact with any metal surface, such as wall plates or other parts of the structure, great care must be taken to properly insulate the space covered by the bracket back. This is accomplished by placing a layer or ring of insulating fiber between the bracket back and the metal surface. In the construction of electric brackets, owing to the body being

brought as close to the wall as possible, a screw back *e* is used. This screw back is furnished with a circular fitting, or pin *f*, which operates along the extended threaded connection of the body with the hickey *g*. In addition to operating on the thread of the body, the screw back is also made so

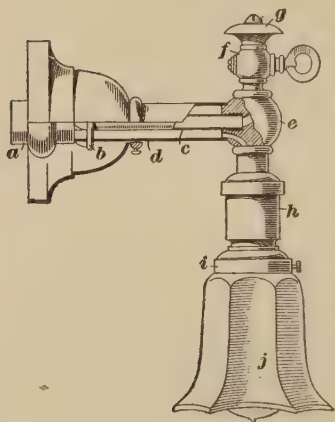


FIG. 12

that it can slide over the fitting between the body and the screw back, thereby allowing freedom while the bracket is being secured to the wall and the wires are being connected.

12. One-Light Combination Brackets.—Brackets constructed for the purpose of illuminating with gas and electricity are called **combination brackets**. A combination stiff wall bracket is shown in Fig. 12, the gas tip being above and the

electric lamp below the arm. Combination brackets for one light are constructed with an insulating joint *a*, a tube finisher *b*, iron pipe *c* for the gasway, tubing *d* for pipe and electric wires, body *e*, cock *f*, burner *g*, electric socket *h*, holder *i*, shade *j*, and lamp.

The insulating joint shown in Fig. 13 is of the same construction as that shown in Fig. 9, with the addition of a hole drilled through the center for conducting the gas. The tube finisher, or hickey, used in the construction of combination brackets, however, is different in design from the electric-light brackets. It is made of cast iron and has four clutches, or claws, *a, a* on the outer edges, as shown in reaction in Fig. 13 and in elevation in Fig. 14. These

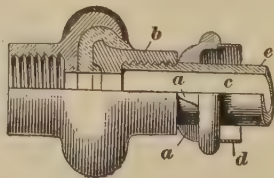


FIG. 13



FIG. 14

clutches touch the insulating joint *b*, Fig. 13, when connected. The wires carrying the current are passed between the clutches, or claws, and along the outside of the iron gasway *c*.

The combination fitting is a metal casting drilled large enough to permit the connection of the gasway and a separate space for the wires. The metal tubing *d* covering the iron pipe or gasway must be $\frac{3}{8}$ inch larger in diameter than the outside size of the iron pipe *c*. This allowance provides a space for the passage of the electric wires to the socket. The tubing is held in position by a seating on the body.

13. Two-Light Combination Brackets.—The combining of two gas burners with two incandescent electric lamps in a bracket is called a **two-light combination bracket**, a good example of which is shown in Fig. 15. The construction is practically the same as that of the one-light combination bracket shown in Fig. 12. Brackets are

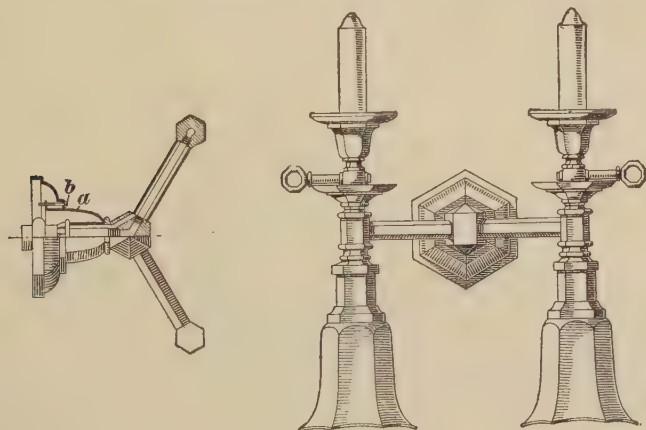


FIG. 15

constructed of various materials adapted to the purpose desired and should be placed about 5 feet 6 inches above the floor. The combination bracket shown in Fig. 15 is furnished with a telescope, or bracket back *a*, designed so that an adjustment can be made by screws *b*, as shown. This device permits the bracket to be brought as close to the wall connection as possible.

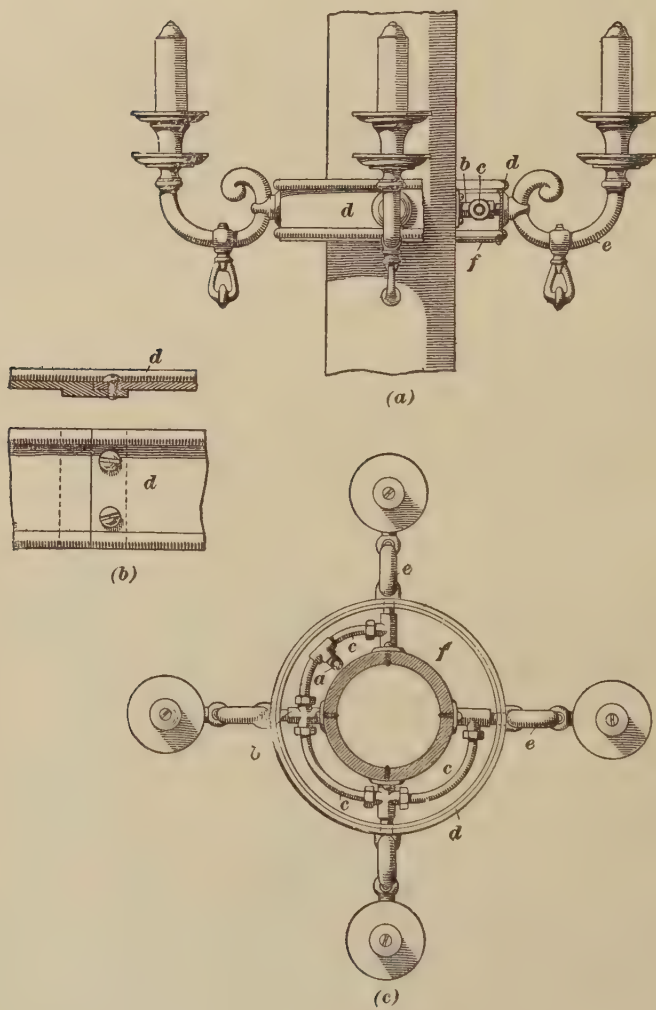


FIG. 16

14. Gas Column Brackets.—Brackets that are attached to columns, or pillars, by bands encircling them are known as **column brackets**. A four-light straight-gas column bracket employing four bent arms in the circle is illustrated in Fig. 16, an elevation of the fixture being shown at (*a*), a detail of the joints in the ring, or band, at (*b*), and a plan view of the fixture, showing the column in section, at (*c*). The manner in which the supply of gas may be furnished to the arms in cases where gas pipes cannot be run inside of the column is shown in Fig. 16. The gas pipe *a*, as shown at (*c*), is run on the face of the column, and supplies gas to the special fittings *b* through horizontal tubing *c*, the joints between the tubing and the fittings being made with unions as shown. The fittings are firmly secured to the column with screws, as shown at (*a*). The ring, or band, *d* is placed in position and is securely fastened there by the arms *e*, which are tightly screwed into the outlets of the fittings. The space between the under side of the ring and the column is closed by a plate *f* made in two sections and bolted to the ring, thus concealing the piping inside of the ring.

If the pipe *a* can be conveniently run inside of the column, it is advisable to do so, for this will insure a neater finish. The outlet of the gas pipe where it would come through the column can then be screwed into the back of one of the fittings *b* previously drilled and tapped to receive it.

15. Electric Column Brackets.—Fig. 17 illustrates, in elevation at (*a*) and plan view at (*b*), a **straight-electric column bracket**, the connections being shown at (*b*). Each outlet fitting of an electric column light must be provided with an insulating joint *a* and a hickey *b*, as shown. Each arm may be provided with separate wires; which are connected to the feed-wire substantially as shown at *c*. The fixture shown in Fig. 17 is also provided with cast bands and sheet-metal plates.

To prevent a ground between the fixture and the column, it is advisable to have the plate *d* at least $\frac{1}{8}$ inch clear of the metal column all around and maintained at that distance

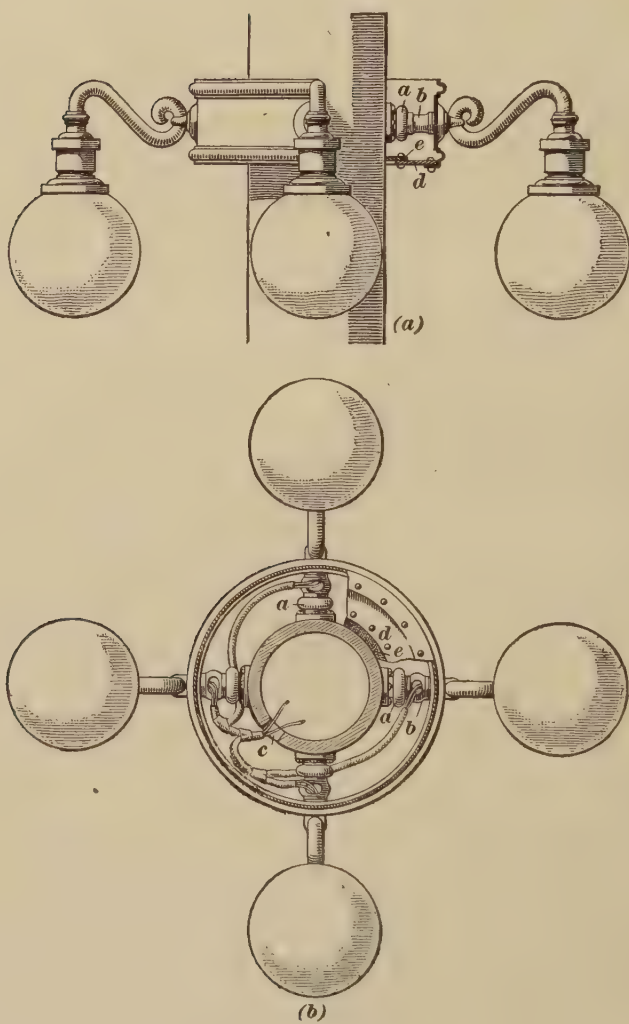


FIG. 17

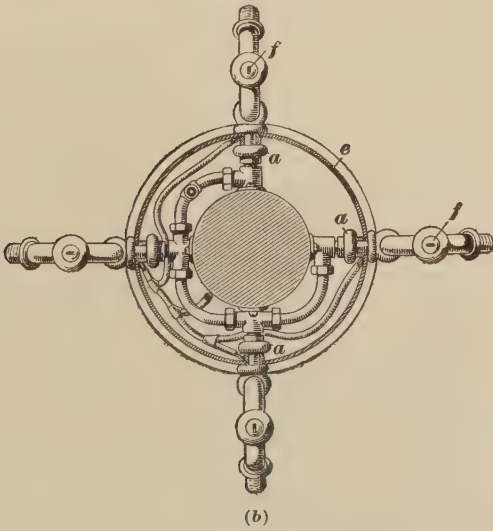
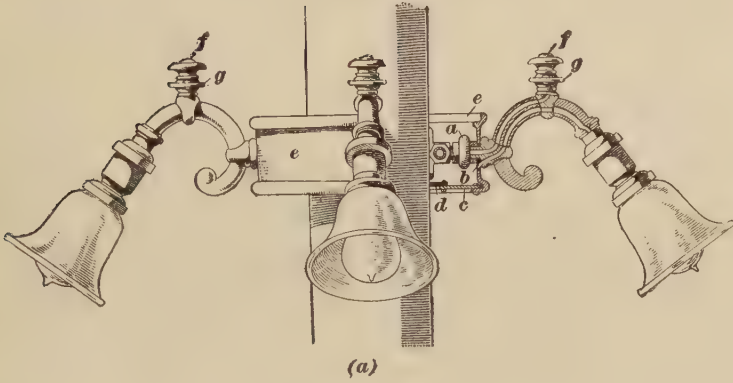
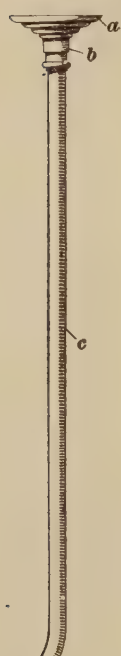


FIG. 18

by a separate ring *e* of suitable non-conducting material, which must be securely bolted to the plate.

16. Combination Column Brackets.—Fig. 18 illustrates, in elevation at (*a*) and plan view at (*b*), a **combination column bracket**. The connections of the arms are shown at (*b*); they are practically the same as those described



for Figs. 16 and 17. The arms of the fixture shown in Fig. 18 are constructed of combination arm tubing, and the fittings are provided with passages for both gas and electric wires. The entrance for gas to the arm tubing is made in the center of the fitting; that for the electric lighting, to the side of the center at the bottom. When separate outlets are used, each must be provided with an insulating joint. An insulating joint is shown located between each **T** on the gas tubing, as at *a*. No hickey is used, as the wires are run into each arm direct, as at *b*. This fixture is also provided with a plate *c* and an insulating disk *d* to close the lower end of the band, or ring *e*. The gas tips of this fixture are located at *f*, and the gas keys at *g*.

PENDANTS

17. Gas Pendants.—Pendants belong to the old order of hanging lamps and lanterns, and are constructed for the purpose of illumination from a suspended connection.

Gas pendants, as shown in Fig. 19, are composed of a ceiling plate *a*, stiff joint *b*, tubing *c*, cock *d*, burner cap *e*, and burner *f*. The ceiling plate is a spun metal shell, and must be large enough to cover the roughness around the gas outlet at the ceiling and of sufficient depth to permit the stiff joint to be connected. The stiff joint is threaded on top to fit the gas outlet, which is generally $\frac{3}{8}$ -inch iron pipe; at the bottom, it is

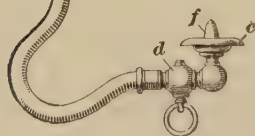


FIG. 19

threaded to receive the tubing or gasway. The cock *d* is placed on the gasway at a point convenient to reach, the distance above the floor being about 6 feet 6 inches or 6 feet 8 inches.



FIG. 20

18. Electric Pendants.—An electric pendant is shown in Fig. 20. Its component parts are practically the same as those used in the construction of an electric bracket similar to that illustrated in Fig. 8.

19. Combination Pendants.—Combination pendants similar to the one shown in Fig. 21 are of the same general construction as combination brackets, except, of course, that pendants require an extra length of tubing. In addition to the regular gas tube, or gasway, a covering tube for the passage of the electric-light wires must be provided. Care should also be taken to have the center of the gas burner not less than 4 inches away from the covering tube, as shown,

so that the gas flame will not injure the finish of the tubing nor destroy the insulation of the electric-light wires.

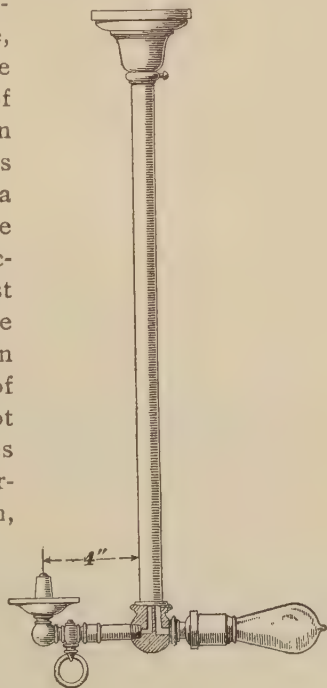


FIG. 21

20. Reflector Pendants.

In Fig. 22 is shown a pendant with two or more gas burners connected to the body by short arms. A reflector suspended above the lights and

enclosing them gives to this style of pendant the name **reflector pendant**. The reflector *a* is of sheet metal, the interior of which is enameled white or is covered with pieces of mirror or art glass held in position by a metallic frame.

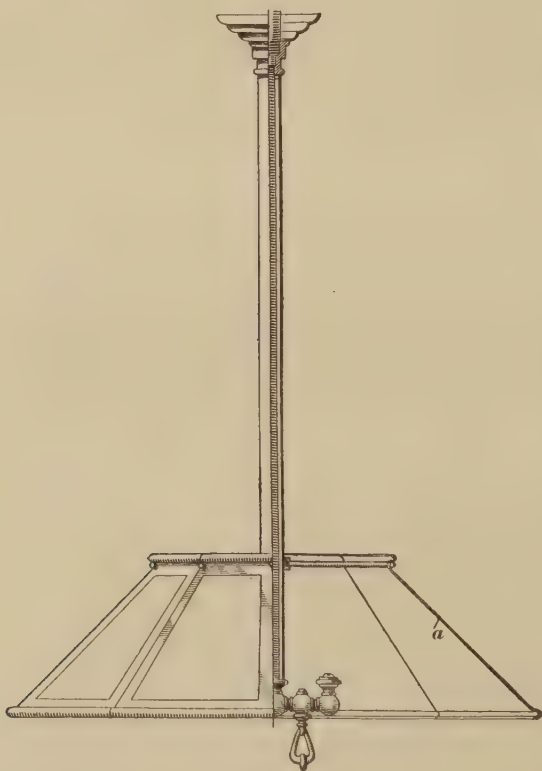


FIG. 22

21. An electric pendant having two or more lamps connected to the body by short arms and covered by a reflector is shown in Fig. 23. In electric illumination, mirrors set in a framework, enameled sheet metal, and ground or opalescent glass are used as reflectors, those made of opalescent glass being in most common use. While these reflectors answer in a way the purpose for which they are used,

they do not diffuse or distribute much more than 50 per cent. of the light. Because of the character of their composition and form, reflectors frequently have a tendency to allow too much of the light to escape in an upward direction or to the sides, while directly below they cast very little reflection in proportion to the intensity of the light.

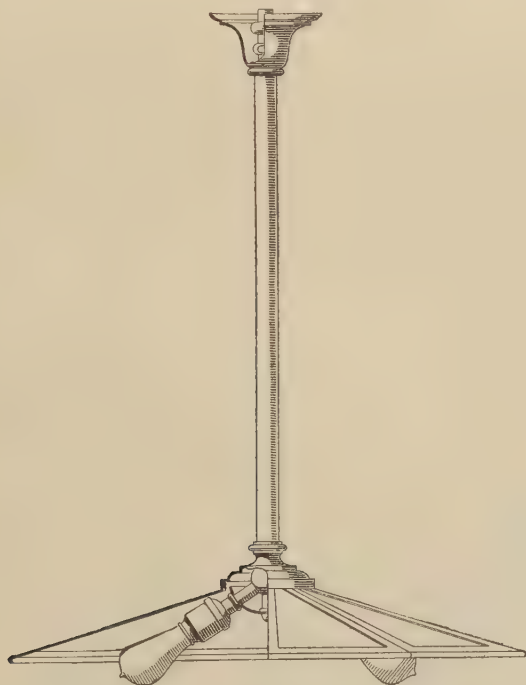


FIG. 23

22. Holophane Shades.—A proper diffusion of the light emitted by either gas burners or electric lamps can be obtained by the use of special kinds of globes, or shades, known as **Holophane**. There are many designs of this ware made to suit different conditions, but they all operate in the same general way; that is, to refract, or bend, the rays of light and thus cause a portion of the light to be projected where desired.

Holophane ware is made of pressed glass, the proper diffusion of light being obtained by a series of vertical prisms on the inner surface and a series of annular compound prisms on the outer surface. Ordinarily, holophane globes are used for throwing the light downwards, as, for example, over a dining-room table.

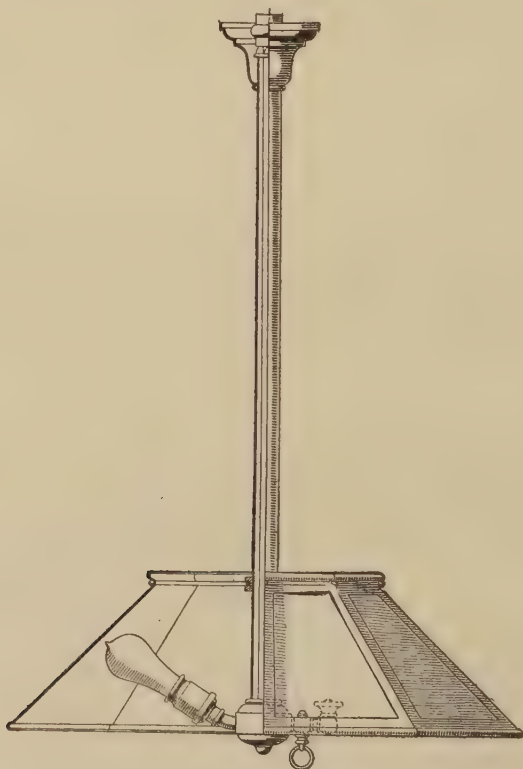


FIG. 24

23. Combination Reflector Pendants.—Combination reflector pendants are made in practically the same manner as those illustrated in Figs. 22 and 23, except that an electric lamp is placed on one side of the tubing and a gas burner on the other, as shown in Fig. 24; or, as shown in

Fig. 25, gas burners may be placed above the reflector, in which case the burners act as emergency lights.

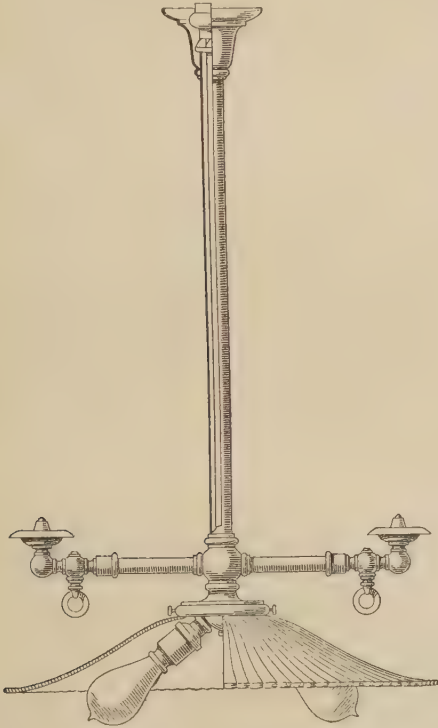


FIG. 25

but the gas jets or electric lamps are entirely enclosed by a covering of glass held in position by a metallic frame. A convenient lantern is constructed with a view to providing space enough for cleaning or to make the necessary changes in the gas burners or electric lamps.

25. Gas Lanterns.—In Fig. 26 is shown a gas lantern, the construction of which embraces the same principles as a gas pendant, with the addition of several

LANTERNS

24. Lanterns are similar to pendants in style and construction,

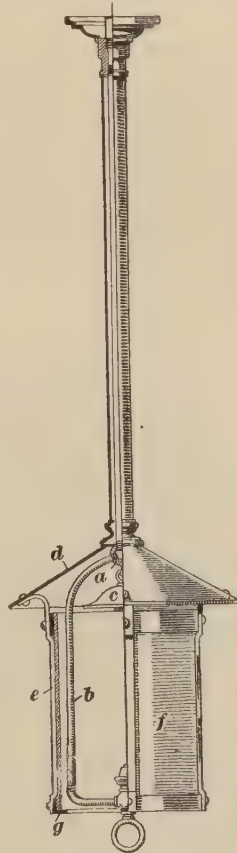


FIG. 26

parts, as follows: The body *a*, which is turned out of bar metal, is fitted to the end of the stem and thus holds the harp *b* in position. The harp is made of brass tubing, and has a cock and burner at the bottom in the center of the glass cylinder *f*. The smoke-bell *c* is of spun metal or glass, and serves to protect

the harp and fitting from the soot and heat of the flame. The hood *d* is fitted to the stem over the body, and the lantern frame *e* is held in position by metal straps, which are riveted or screwed to the hood and frame. The glass cylinder *f* is placed in the lantern frame inside of the bands *g* and straps, and is held in position by the bottom band, which is attached to the frame.



FIG. 27

26. Electric Lanterns.—The stem of an electric lantern is generally constructed in the same manner as an electric pendant, but in Fig. 27 is shown an electric lantern in which a chain is used for the stem. The structural parts of this lantern are an insulating joint, hickey, screw canopy, chain fitting *a*, chain *b*, tube ring *c*, ring fitting *d*, iron stem *e*, body *f*, arm *g*, socket *h*, lamp *i*, holder *j*, and globe *k*.

The screw canopy at the ceiling is adjustable, and is fitted to the top of the stem, which, as already stated, is in the form of a chain. In making connections, the screw canopy is adjusted so

as to allow a proper wire connection to be made, after which it is raised close to the ceiling, screening from view the insulating joint and hickey, and secured in position by means of a circular ring or a screwed fitting. The wire connection of Fig. 27 is made through the insulating joint and hickey, the wires passing through the center of

the fitting at the end of the canopy, a hole being bored through this fitting to allow for their passage. The use of a chain stem makes it necessary for the wires to be exposed from the fitting to the tube ring, because, if they were passed through the links of the chain, there would be danger of the wires becoming bared, thereby risking a contact with the metal parts of the chain. The wires are passed through a hole in the tube ring, then through the iron stem and body, and are finally connected to the socket, thus completing the connection. The holder *j* is a spun shell and should not be less than No. 16 gauge in thickness. It is provided with four setscrews to hold the globe in position.

27. Combination Lanterns.

Combination electric and gas lanterns must be designed with a view toward allowing a certain amount of air to pass through them. If they were made air-tight, the heat of the gas flame would burn the insulation of the electric wires, besides depositing soot on the inside of the lantern. Combination lanterns are constructed in practically the same way as combination pendants.

In Fig. 28 is shown a box-shaped lantern, the top, or hood, of which is provided with openings at *a* to permit heat to escape from the interior. The lantern frame and hood are usually made of cast metal, but if sheet metal is employed, No. 16 gauge or thicker will be found very satisfactory. All joints should be brazed or riveted.

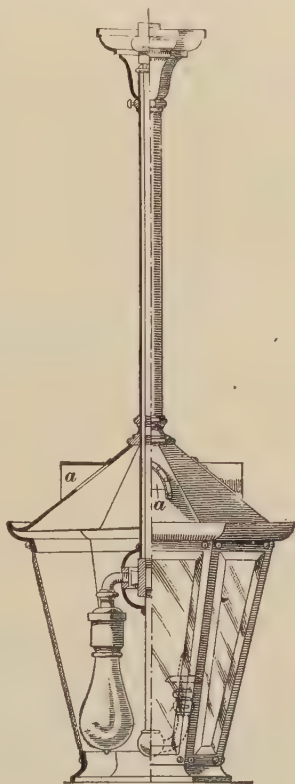


FIG. 28

In constructing a box lantern, means should be provided for cleaning the interior and for changing the gas burners and lamps. This may be accomplished by having one of the sides connected to the frame with hinges, so as to allow the leaf to swing outwards; when closed, it is secured by a small wire drop bolt that fits into a socket on the frame. The gas burner must be placed at a distance not less than 2 inches from the center of the stem and away from the electric lamp, so as to keep the direct heat of the gas flame safely away from the electric connections.

28. Bracket Lanterns.—Lanterns combining a bracket and a lantern in construction are called **bracket lanterns**,

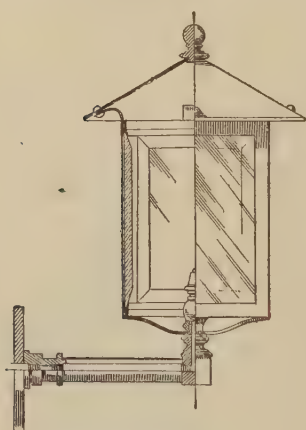


FIG. 29

and are used for street and open-air illumination. A gas bracket lantern is shown in Fig. 29. This fixture is very much like the one shown in Fig. 3, except that a lantern is placed on the bracket. The parts of bracket lanterns are always built on a larger scale, as they are exposed to more danger than indoor, or house, brackets.

In Fig. 30 is shown an electric bracket lantern that is made practically the same as the fixture illustrated in Fig. 7 with the addition of a lantern.

In cases where the bracket lantern is fastened to a stone wall, a casting, or tripod, shown in Fig. 30 (*b*), is used. The tripod is secured to the stonework by expansion bolts, as shown at *a*, a sliding or adjustable back *b* being used to cover the tripod connection.

29. Combination Bracket Lantern.—A combination bracket lantern is shown in Fig. 31, and is of a similar construction to the combination bracket shown in Fig. 12, with the addition of the lantern. This fixture is furnished with a telescope back—a bracket back by which, through the

adjustment of screws *a*, it is screwed up tightly between the fitting *b* and the wall.

30. Hanging Bracket Lantern.—When the position of a bracket lantern is reversed, it is called a **hanging**

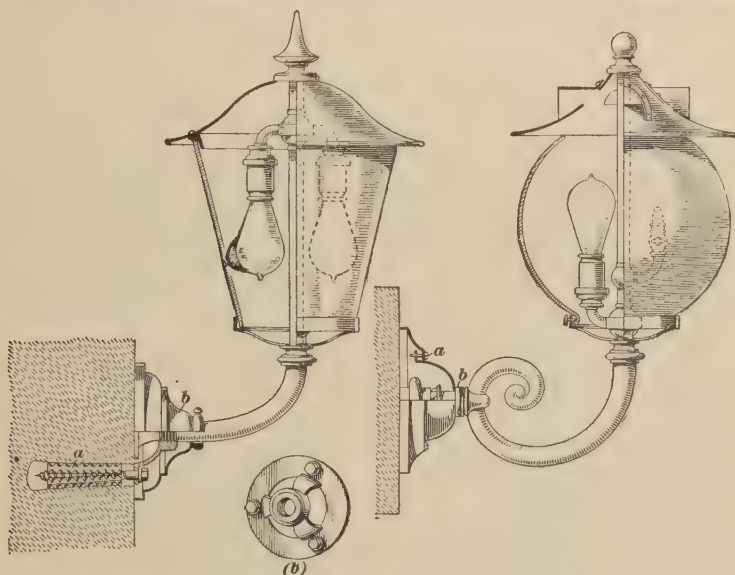


FIG. 30

FIG. 31

bracket lantern. By reversing Fig. 31, this effect can be obtained; the ventilating hood, however, would then be placed over the top of the globe

CHANDELIERS

31. Introduction.—The arrangement of a number of lights in a circular form on a suspended framework, for the purpose of giving additional illumination with perfect security, led to the construction of the **chandelier**. In the middle ages, the lights were placed in one plane; that is, although there were several rings of lights on a chandelier, they were placed on one level, no light occupying a higher or a lower position than any other in its respective circle. The

principle of illumination in a circular form was still adhered to in the Renaissance, but the lights were placed on arms, or holders, separately connected to the body of the chandelier. In this era, there also appeared chandeliers having an alternation of lights in different rings; this style of

chandelier is still in use.

In the middle ages and the Renaissance, the use of candles and oil as illuminating factors provided but a small field for bringing the chandelier to an advanced degree of efficiency, although the artistic sense of our forefathers was fully gratified, as is aptly illustrated in the beautiful ornamentation of their works that are still preserved. The use of gas and electricity as agencies of illumination has brought the chandelier of the present day to a high state of perfection. And the facility with which these products can be handled has done much toward making the chandelier a very popular method of illumination.

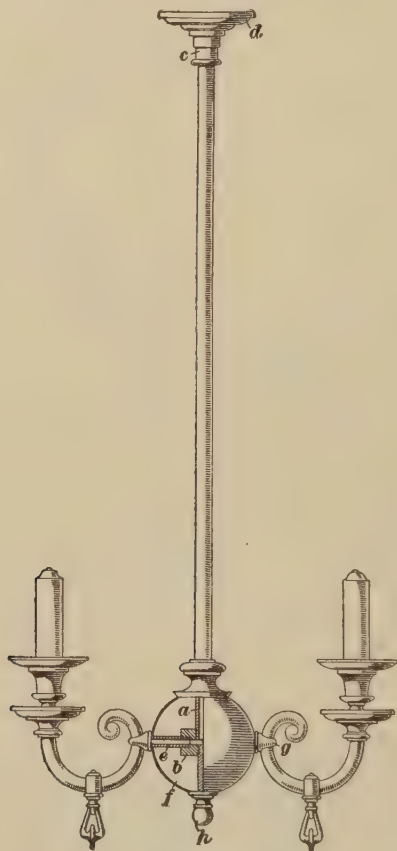


FIG. 32

32. Construction.

Chandeliers are made in various styles and sizes, and can be obtained for straight-gas, straight-electric, or combination work. Figs. 32, 33, and 34 show chandeliers intended for the general illumination of rooms in dwelling houses. For this purpose, they are usually made with from two to six arms; but for meeting halls,

churches, theaters, etc., where a great volume of light is required, they are made quite large and are equipped with more arms or jets. When the agency of illumination is gas, a chandelier may be constructed with a large variety of clusters of arms, numbering thirty or forty lights, or even more. All parts of chandeliers as well as parts of other fixtures must be constructed according to the size and weight of the fixture; the greater its proportions the stronger must be its construction.

33. Gas Chandeliers.—In Fig. 32 is shown a **straight-gas chandelier** that has only two arms, but six, or even more, may be embodied in this construction. This fixture is composed of an iron gas tube *a*; the lower end of the tube is screwed into a hollow gas body *b*, and the upper end is secured to the gas pipe at the ceiling by means of a brass coupling *c*. A spun shell *d* conceals the gas pipe, or gas outlet, at the ceiling. The gas body is provided with nipples *e* to which the arms are connected, and when a great variety or many clusters of arms are required on a chandelier, a separate body is attached to the stem for each section, or cluster. The body is covered with a spun shell *f* having as many holes as there will be arms. When the arms are connected to the body, the fitting *g* on the arms must be brought close to the body shell. A pendant knob *h* screwed to a wire connected to the bottom of the gas body and running through the shell serves to hold the shell *f* in position. The other parts of the fixture are similar to those described for other gas fixtures.

34. Electric Chandeliers.—The **electric chandelier** shown in Fig. 33 is constructed on the same principles as an electric pendant, with the addition of the body *a*, to which the arms are connected, a spun shell, and a pendant knob. The body used in electric chandeliers is made of cast iron or brass, and is provided with a tapped hole on the top and one on the bottom to connect with the stem and the wire for the pendant knob. The sides are furnished with tapped holes, into which the arms are inserted and secured by setscrews.

The arms on an electric chandelier may be curved upwards or downwards, or they may be at right angles to the stem. As incandescent lamps are employed for illumination, there can be no possible danger to the fittings from heat and

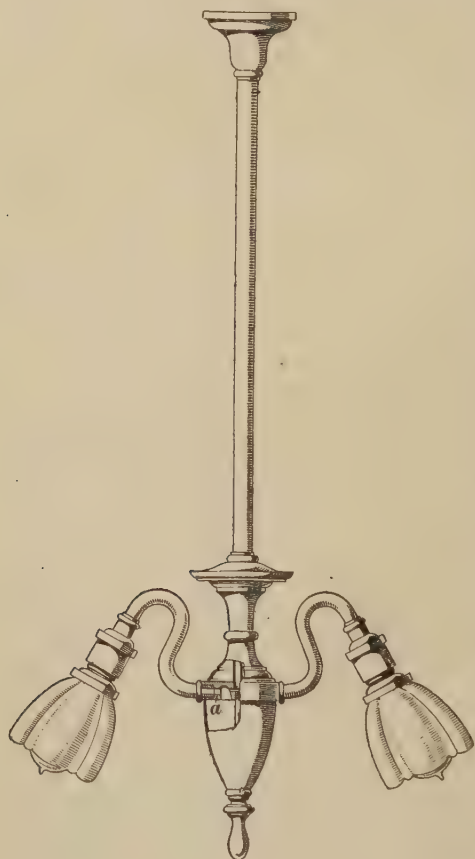


FIG. 33

smoke, as would be the result if gas burners were placed on chandeliers in any position other than vertical.

A chandelier with the lights encircling the stem on one or several metal bands of varying circumferences, is called a *corona fixture*. The connection to each electric arm holding the bands in position must be covered with a spun shell, which, in addition to hiding the connections of the arms, adds to the decorative effect of the fixture. These spun shells are made in various sizes and shapes to suit the number of arms to be screened at their connections. The

bands employed are of varying sizes, to facilitate illuminating in concentric circles; that is, a small band is placed within the circumference of a larger one, thereby reducing the size of the shadow cast by the center lights. When properly designed this makes an attractive fixture.

35. Combination Chandeliers.—Chandeliers in combination present equally as great an opportunity for the arrangement of lights as the straight-gas or straight-electric fixtures. The fixture shown in Fig. 34 could be furnished with separate gas arms outside of the fixture, and in place of the metal shell *a* with the pendant knob *b*, a ground-glass globe might be substituted, illuminating the globe with electric lamps. This arrangement would be very suitable for a hallway or corridor. This type of fixture could also be provided with a combination of lights on the outside of the fixture, or a corona fixture could be constructed with the combination arrangement of lights. In fact, there are many combination arrangements possible, with all styles of fixtures, which are too numerous to be described here.

Taken as a whole, chandeliers afford many opportunities to illuminate from almost all points in the body of the fixture. The arms on a chandelier are at times very plain, as in a cheap fixture, while cast arms highly ornamented, plated, burnished, or oxidized are used on costly fixtures. C- and S-shaped arms when used on chandeliers add to the decorative effect. Chandeliers can also be provided with cast ornaments along the stem.

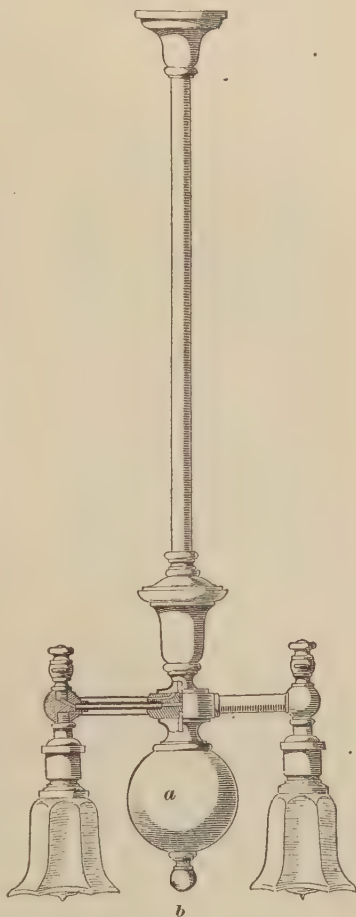


FIG. 34

36. Arrangement of Lights.—Lights may be arranged in tiers or circles on an electric chandelier or other fixture without any consideration of position; but when the fixture is of the combination type, the gas arms must always be placed on the upper tier. This fact should always be borne in mind in the practical designing of fixtures, for electric lamps, fittings, and connections on any style of combination fixture must be protected from the heat of the gas flame by locating gas points of illumination at least 4 inches from any surrounding metal, etc.

37. Space for Wires.—With the introduction of electricity as an illuminant, the wiring of chandeliers was often attended with disastrous results, owing to electric wires being stripped of their insulation while being passed through the shell and through holes provided for them in the various sections. Experience has taught that the wires should be placed inside of the stem tubing and that the shell must be of a size large enough to permit a free passage (about $\frac{3}{8}$ inch diameter greater than gas pipe) of the wires from the canopy to connections at the body. In connecting the wires to the sockets, the spun shell must be removed and this may be accomplished by taking off or unscrewing the pendant knob. After the connection has been made, the spun shell and the pendant knob are replaced.

38. Chandelier Details.—The body fitting commonly used in the construction of an electric chandelier is shown in Fig. 35 (*a*). The stem is screwed into the tapped opening *a*, and the arms into the tapped openings *b*, a setscrew being used in the under side to prevent the arms from twisting after having been screwed up and properly alined. The lower part of the fitting is open, a bridge *c* being cast across to support the rod attached to the pendant knob. This rod is screwed into the tapped opening *d*. Space is allowed for the wires inside of the fitting and around and under the bridge.

Fig. 35 (*b*) shows how the body fitting for a combination chandelier may be made. The tapped opening *a* is screwed

to the gas tube, and the space *b* is filled with gas. The gas arms are screwed to the tapped outlets from *b*, as at *c*. The space *d*, which is open through the body, is to receive the

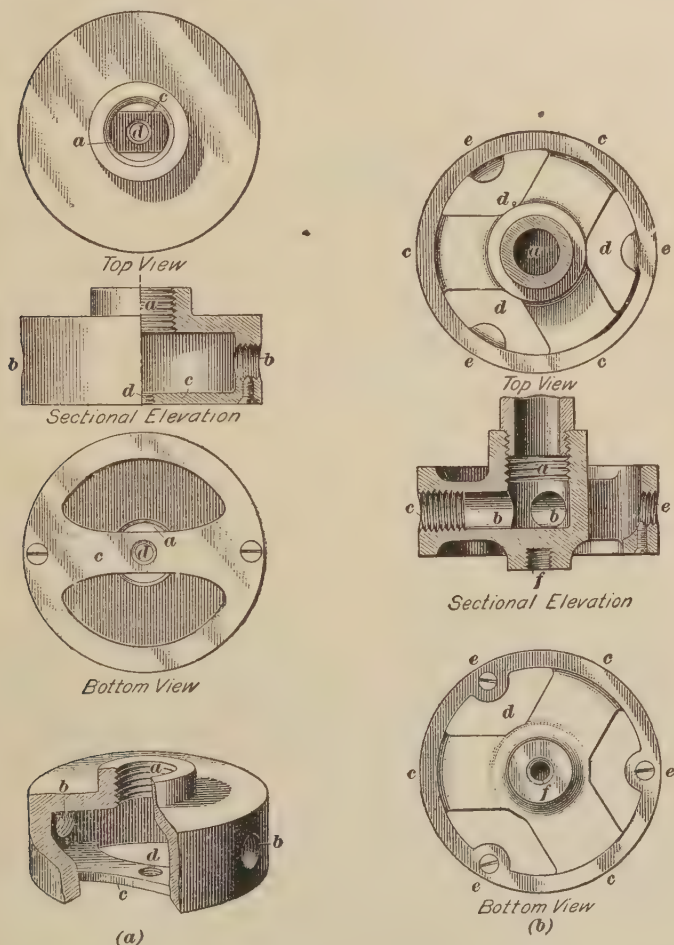


FIG. 35

wires, the tapped outlets for the electric arms being located at *e*, with setscrews under them, as shown. The rod for the pendant knob is screwed into the tapped opening *f*. The diameter of the body fitting and the number of gas and

electric tappings depend on the number of arms to be used on the chandelier.

39. An illustration of the parts used in the construction of the spun shell of the fixture shown in Fig. 34 is given in Fig. 36. The stem tubing rests on the spun neck *a*, which is furnished with a seating that fits the stem tubing with a snug joint. The part *a* rests on the section *b*, *b* rests on *c*, and *c*

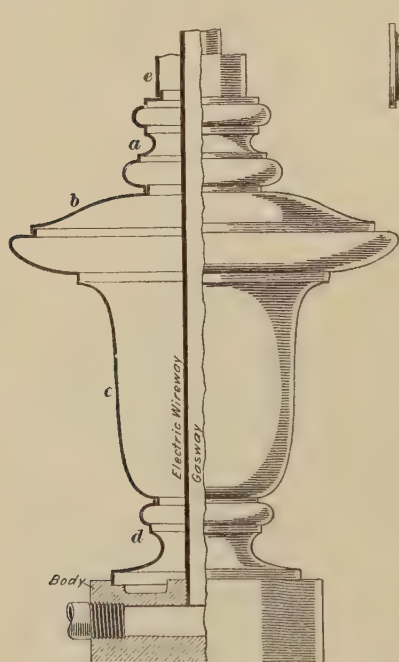


FIG. 36

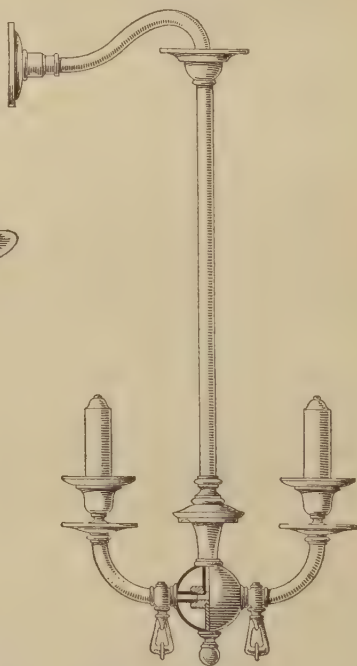


FIG. 37

on *d*, the bottom section *d* resting on the body. All the parts above the body, that is, the shell and stem tubing, are held rigidly in position by the hickey at the upper end of the tubing, which is screwed down on the top of the stem tubing *e*.

40. Toilet Fixtures.—Toilet fixtures or bracket chandeliers are constructed the same as chandeliers, but on a smaller scale. They are placed in front of mirrors, bureaus, and dressers, in bedrooms and dressing rooms, and are

connected to the wall by a bracket arm. The perpendicular drop of toilet fixtures is generally 28 inches from the wall outlet to the bottom of the fixture.

The distinguishing feature of the toilet chandeliers is the bracket used for suspending the fixture. Several illustrations of toilet fixtures are shown here, in which the construc-

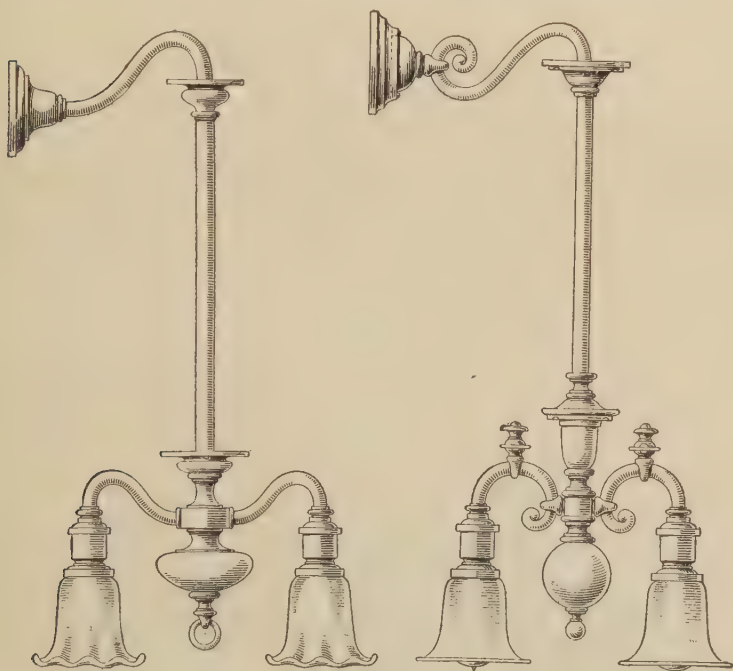


FIG. 38

FIG. 39

tion is practically the same as the chandeliers previously represented. Thus, in Fig. 37 is shown a gas toilet fixture similar to the chandelier shown in Fig. 32; Fig. 38 represents a straight-electric toilet fixture like the chandelier shown in Fig. 33; and Fig. 39 is a combination toilet fixture similar to the one shown in Fig. 34.

DINING-ROOM AND LIBRARY FIXTURES

41. The fixtures for dining rooms and libraries are designed and constructed according to the same general principles that govern chandeliers, but their light is concentrated

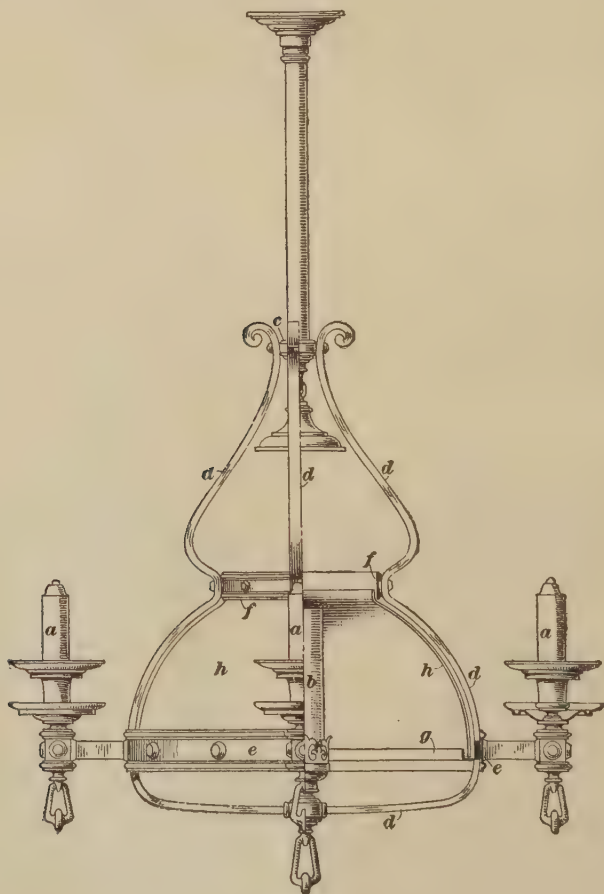


FIG. 40

on the dining-room or library table. For this reason these fixtures are usually furnished with a glass dome, or shade, which easily distinguishes them from the chandelier.

Fig. 40 illustrates a gas dining-room fixture of five lights. This fixture is provided with four lights on the outside of the dome, shown at *a*, and one in the center, as at *b*. The outside lights are used for illuminating all parts of the room outside of the area occupied by the dining-room table, while the center light is used chiefly to illuminate the table.

This fixture consists of a stem fitted with a body, as at *e*, four rods *d* of flat tubing, and two bands *e* and *f*. The gas is conveyed to the arms through only three of the tubes *d*, the fourth being a dummy or movable rod attached by setscrews at the top and bottom. This arrangement permits the rod to be moved to one side, thereby affording an opportunity to change the dome, which can only be taken out of the fixture through the space thus provided. The top band *f*, which is made of cast brass,

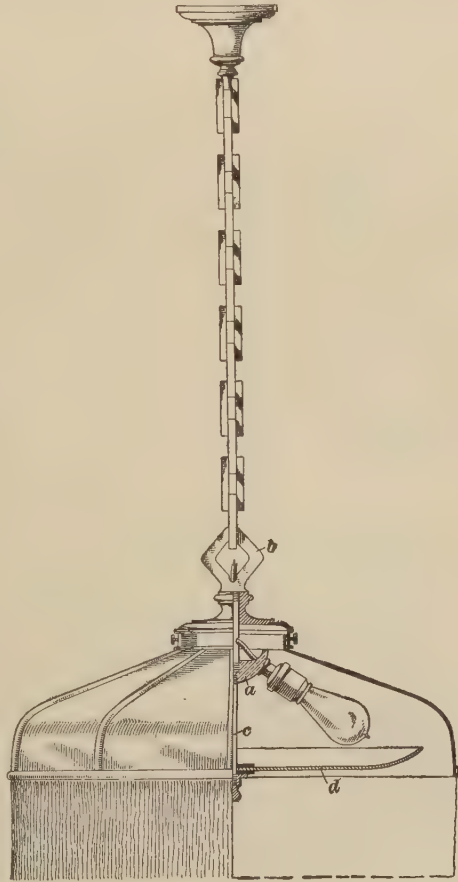


FIG. 41

is placed inside of the rods, and is held in position by four setscrews inserted through the rods from the outside. The bottom band *e* is on the outside of the fixture, and is held in position by the connections of the arms, being furnished on

the inner side with a spun shell *g* on which the glass dome *h* rests. Cast fittings brazed at the connection of the band and the rods serve to hold the connection of the outside arms rigid. The outside arms are frequently made of flat tubing, with fittings brazed on the ends. The flat raised nailheads shown on the bands and end fittings are not necessary, but are simply attached as ornaments.

42. In Fig. 41 is shown an electric chain-stem fixture with an art-glass shade and a silken fringe. Art-glass shades are constructed in sections, which are held in position by a metallic frame. The silken fringe is sewed to a sheet-metal band, which is connected to the shade by setscrews. The cluster of lights on the body *a* is held in position by an iron pipe connected to the diamond loop *b*. This iron pipe is furnished with a fitting at the end, to which is connected the rod *c* for supporting a disk *d*. This disk is usually made of ground or opalescent glass, and is used to moderate the intensity of the light, making the illumination soft and agreeable to the eyes.

43. Combination Dining-Room Fixtures.—A combination fixture for dining rooms is illustrated in Fig. 42, and consists of a split canopy *a*, silk stem *b*, ring fitting *c*, spun shell *d*, cast band *e*, gas arms, electric-lighting arms, combination body *f*, lamps, and a conical art-glass shade *g* with cast band *h* and silk fringe *i*.

The split canopy is a spun shell divided into two equal sections, which are joined together by two metal straps when the fixture is installed. These straps are soldered to one section of the spun shell, one strap on each side and inside of the canopy at the line of bisection. The free end of each strap is provided with screw holes, to receive the screws inserted through the other section of the canopy. The silk stem is made by covering brass tubing with woven close-fitting silk. This silk covering is attached to two wooden knobs, also covered with silk, one being placed on the stem directly under the canopy and the other on the stem about 5 inches above the ring. The tube between the bottom

knob and the ring is screened by a silken tassel, as shown, and the ring is connected to the stem by a fitting, through one side of which the gas flows, while the electric wires enter through the other, the ring being divided accordingly. A similar fitting connects the fixture to the ring.

From the fitting at the bottom of the ring, an iron pipe with a gas body is connected, to act as a gasway for the arms. The body on which the cluster of electric lamps is arranged is held in position by a pendant knob, the stem, or rod of which is screwed into the bottom of the gas body. The fringe shown in Fig. 42 is called *knotted fringe*, and is also made of silk, being sewed to the cast band of the shade.

The construction of dining-room and library fixtures is practically the same, as is also the principle of illumination. Each

serves to light up a table, and, when necessary, lights are provided for the space beyond the area of the table.

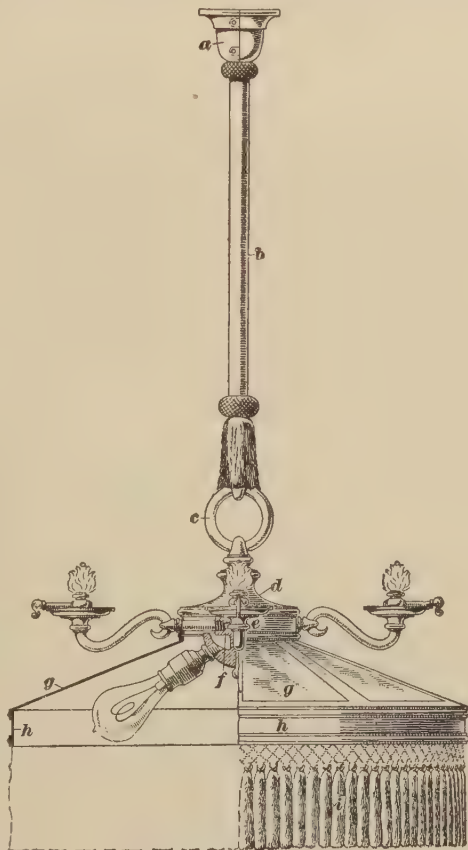


FIG. 42

44. Various Designs.—In order to show the diversity of the designs of dining-room and library fixtures, some

arrangements of lights differing from those just illustrated and described will be given. For instance, the design shown in Fig. 40 could be made up of only two lights on the outside and one on the inside. In this case, the supply of gas would necessarily have to pass through only two of the flat tubes *d*.

Owing to the stem in Fig. 41 being made of links, lights could not very well be added to it; but at the fitting at the end of the diamond loop, from two to six lights could be placed, or, considering the size of the fitting and the connections, practically as many lights as could be added thereto. Too many lights should not be around a central point on any fixture, however, and a reasonable space should always be allowed between the arms, or sockets. The fixture shown in Fig. 41 might also be provided with a body under the canopy at the ceiling to which four or five lamps could be attached, thus giving a better general illumination.

45. While the usefulness of the fixture must not be overlooked, it should be remembered that the public demands and expects an artistic treatment that will help in decorating and furnishing the room.

Being a combination fixture, many additions and alterations may be made to the fixture shown in Fig. 42. It may be provided with a body and lamps, under the canopy, the same as an electric fixture. Clusters of lights can also be placed along the stem about 1 foot from the ceiling. This arrangement will bring into use a combination body, which can be covered with a spun shell. When a silk-stem fixture is furnished with a cluster of lights on the stem, the silk covering must be in two parts, and each part provided with its own complement of knobs.

The emergency lights in Fig. 42 may be placed around the bottom band *h* if desired. When constructed in this manner, a connection must be made to the gas body at the end of the stem by running metal tubes along the ribs of the shade and placing them either on the outside or the inside of the shade. The lighting of electric lamps on fixtures that are beyond

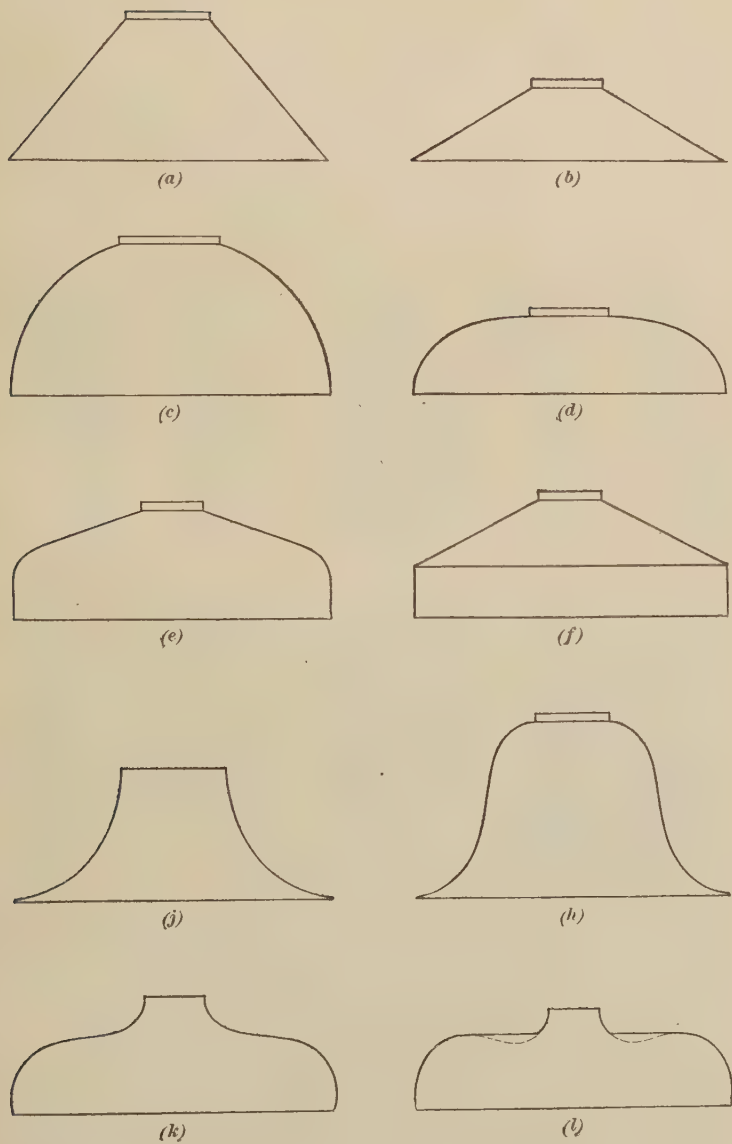


FIG. 43

reach may be controlled by a push-button switch suspended from the pendant knob of the fixture.

46. Domes and Shades.—The glass or mica domes and shades used for dining-room and library fixtures may be of almost any shape. They are generally constructed, however, so that they form geometrical figures in plan. A few designs in common use are shown in side elevation in Fig. 43. Transparent glass is rarely used for shades, translucent,

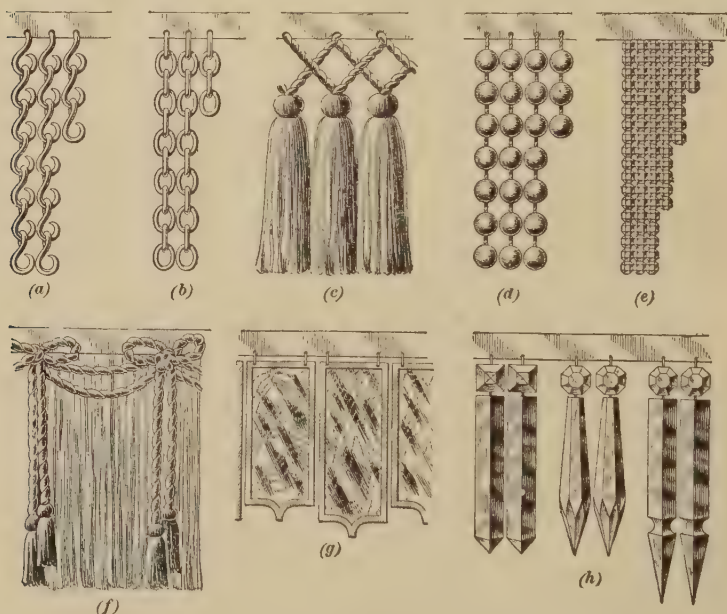


FIG. 44

opalescent glass of different colors being usually employed. In some localities where pieces large enough to fit the frame can be obtained, mica is more popular than transparent glass.

47. Beads and Glass Balls.—Electric bulbs and glass balls are frequently ornamented by means of cut beads strung on wires. Very good effects are sometimes obtained in this way.

48. Fringing.—The fringing for dining-room and library fixtures are various, almost anything to suit the fancy being used. A few popular styles are shown in Fig. 44. At (*a*) is shown a metal chain fringing having S-shaped links; and at (*b*), one having oval links; at (*c*) is shown a fringing made of silken tassels; at (*d*), metal beading on wire or silk threads; at (*e*), glass beads; at (*f*), silken ropes and threads; and at (*g*), art glass or mica incased in a metal frame. At (*h*) are shown some forms of prismatic glass used as fringing, which are again coming into extensive use.

ART GLASS

49. Making Art Glass for Shades.—The general method of manufacturing art glass is as follows: Pots containing glass of the different natural colors are placed beneath openings in a brick oven shaped like a beehive. The colors necessary to form the desired shade of glass are dipped from the pots, with ladles, and poured, through a funnel, on a steel slab. Here the mixture is manipulated with a trowel until it is smoothed somewhat and has approximately the desired consistency. It is then run through a roller located at the end of the steel slab, which gives it the proper thickness and at the same time imparts a smooth or rough back to the glass, as desired. The plate, or panel, of glass is then placed on another steel slab, where it is allowed to cool, after which it is ready for shipment.

The mixing of the natural colors to form the various kinds of art glass is a secret that is jealously guarded by manufacturers, and differs widely in the various concerns engaged in this work.

50. Shaping Art Glass.—Art glass highly ornamental in appearance comes in sheets or panels. When a certain shape and size is desired, the glass is cut to the required size and placed in a sheet- or cast-iron mold. A quick method of bending these sheets is as follows: The mold containing the glass having been placed in a sheet-metal box, a flame, composed of gas and air is played lightly on the glass until it

becomes hot, when the intensity of the flame is increased by means of air pressure. The glass is then pressed on the metal mold with a steel tool resembling a poker, after which it is allowed to cool. Great care must be taken in removing the glass from the sheet-metal box, as a current of cold air or draft will cause the glass to crack.

Double, or **S**, bends, while difficult to execute, are at times attempted in one piece, but owing to the danger of breakage, the general process employed is to make **S** bends in two pieces. These pieces are afterwards joined with ornamental bands, and do not detract from the general appearance of the finished article.

51. Color and Finish of Art Glass.—With the exception of ruby and opal, all colors of art glass bend readily. The former is one of the most difficult colors with which to effect a bend so as to retain the natural, or ruby, color. Often, in the process of bending, this color is lost by heat. All ruby glass contains a large amount of gold, but some manufacturers manage to obtain an excellent color with a small amount of this metal; so that if a bend is attempted the gold is dissipated and the color is lost. Glass of an opal color is very brittle in character, and is subject to a large amount of breakage. It is not an infrequent occurrence to break a number of panels before the desired shape is successfully produced.

In endeavoring to obtain a satin finish in glass, sand should not be used, as the pressure of the sand so weakens the glass that it breaks easily. This is especially true of Etruscan glass, which is very thin, has little body, and is drawn tighter than ordinary glass. The best way to obtain a satin finish is by the use of acid. While a satin finish really makes the glass rough to the touch, it presents a smooth, neat appearance.

CEILING LIGHTS

52. Chandeliers having short stems or no stems at all are called **ceiling lights**. As these lights are generally straight electric, they are controlled by switches or switchboards, the switches being used in private houses and located

at convenient points in the walls, and the switchboards in churches, theaters, and public buildings.

53. Examples of Ceiling Lights.—In Fig. 45 is shown a one-light ceiling fixture that is constructed the same as a one-light electric pendant; it is furnished with a screw canopy.

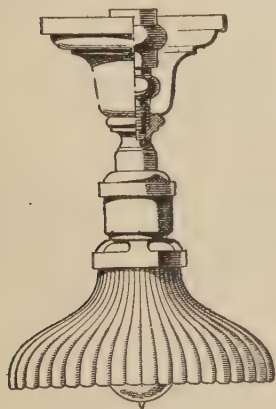


FIG. 45

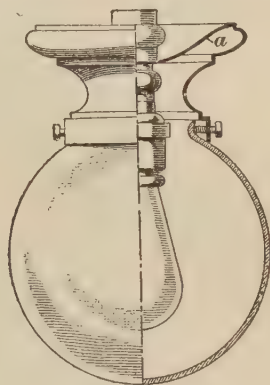


FIG. 46

Fig. 46 shows a one-light ceiling fixture constructed with a spun shell and furnished with a ground-glass globe, or ball. The spun shell is placed on the ceiling and is held in position by a holder *a*, which in turn is secured by the connection of the hickey with the insulating joint. The globe, or ball, is held in place by setscrews on the shell.

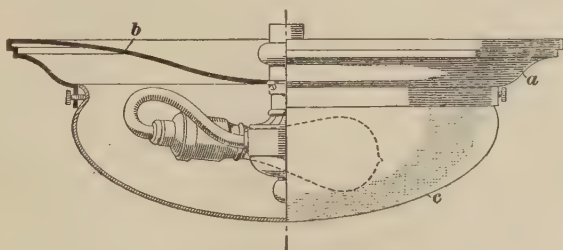


FIG. 47

54. A cluster ceiling light with a spun shell and a ground-glass dish is shown in Fig. 47. The spun shell *a* is held in position by a holder *b* that is secured by the

connection of the body with the insulating joint. The ground-

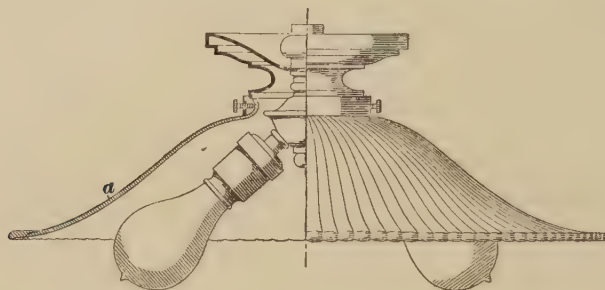


FIG. 48

glass dish *c* is used to soften the intensity of the light and is held in place by setscrews in the spun shell.

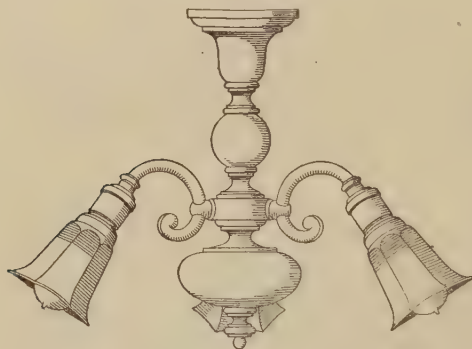


FIG. 49

Fig. 48 illustrates a ceiling fixture that is constructed practically the same as that shown in Fig. 47; it is furnished with a Holophane shade, or reflector, *a*.

Fig. 49 shows a ceiling fixture that is made in practically the same manner as

an electric chandelier provided with bent arms.

55. Carved Wooden Ceiling Lights.—A carved wooden ceiling fixture with depending electric-light globes is shown in Fig. 50. Air-dried hardwood with every vestige of moisture extracted is used for this fixture; and as its size ordinarily precludes the possibility of manufacturing it in one piece, for large hardwood timber is scarce, it is made up in sections. These sections, or blocks, are glued together to form the body, being placed crisscross in grain so as to prevent the possibility of cracking or splitting. When the body has been carved, it is usually gilded, which effectually hides all the joints that were formed by the blocks.

As shown in the illustration, the construction of the wooden ceiling light requires a wooden body with metal husks *a* at the corners, in which to place the lights, and a separate pendant knob. The lamps are held in position by brass tubing *b*, which is secured with locknuts as shown. The wiring is made from the insulating joint, passing freely through the brass tubing, and connecting to the socket of the lamp which is screwed to the bottom end of the tube. The pendant knob *c* is of carved wood, and is provided on top with a threaded iron flange *d* that is secured to the knob by three woodscrews. This flange is screwed to an iron pipe *e* that connects with the insulating joint, and thus holds the ceiling fixture in position.

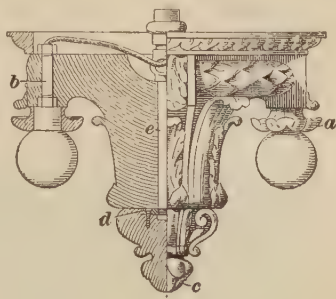


FIG. 50

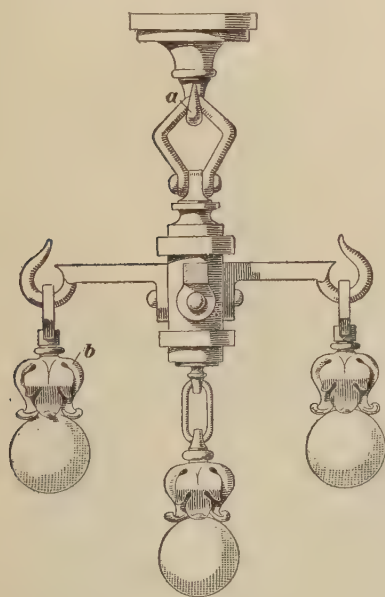


FIG. 51

56. Hammered-Iron Fixtures.—A hammered-iron ceiling fixture having all parts square in section is illustrated in Fig. 51. The construction employs a canopy with a hook fitting *a*, a diamond-shaped loop, a body, four hook arms on which hammered-iron husks *b* are suspended by means of links, and one center light. The diamond loop is welded to the hook fitting under the canopy, and the body of the

fixture is made of wrought iron; the arms also are of wrought iron and are riveted to the body. The links on the ends of

the hook arms are provided with a fitting to which the hammered husks are connected. The center light is supported by a link fitting that screws to the body. The whole fixture is held in position by an iron pipe that connects with the insulating joint and the hook fitting under the canopy. This fixture is wired in the same manner as an ordinary electric chain-stem fixture.

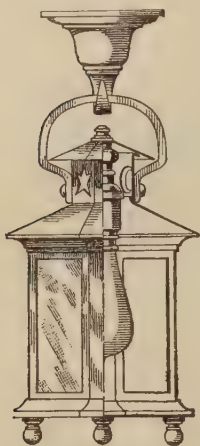


FIG. 52

57. Lantern Fixtures.—Fig. 52 illustrates a lantern ceiling light made up of a canopy having a hook fitting and a semielliptic loop that is riveted or screwed to an octagonal lantern. This fixture is wired in a manner somewhat similar to chain-stem fixtures, the only difference

being that the wires are connected directly to the socket from the tripod or insulating joint.

58. Hammered-Brass Lights.—In Fig. 53 is shown a hammered-brass ceiling light consisting of a hammered canopy, a ring chain, a hammered body with cast arms finished in imitation of hammered metal, and two hammered hoods having shades composed of mica in brass binding. This fixture is made of



FIG. 53

about No. 12 gauge metal and is built up in sections. The sections are first cut to the size and pattern desired and then

hammered, an operation that requires much skill in order to give the parts a perfect finish and form, after which they are bent to shape and then riveted together. The wiring of this fixture is the same as that employed for Fig. 51.

59. Crystal Ceiling Lights.—A crystal ceiling light made up of brass bands fringed with glass prisms is illustrated in Fig. 54. The body of

this fixture is constructed with five horizontal bands *a*, which are held in position with four or five vertical straps, as shown at *b*. The top is a spun shell, which is fastened to the insulating joint and the vertical strap. The glass prisms are attached to the bands by metal hooks formed by the wire passing through the prisms. All

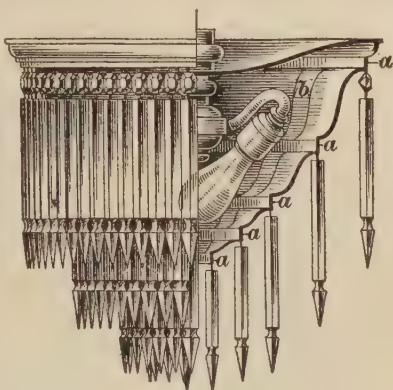


FIG. 54

inside metal work of ceiling lights that are provided with crystal prisms should be of plated nickel or silver, so as to insure proper reflection of the light. This treatment also provides metal work that is nearly the same general color as the prism.

CANDELABRA

60. Introduction.—The candelabrum was, as its name indicates, primarily used to bear or hold candles and has a socket or pricket on its end. When lamps replaced candles, this fixture underwent no material change in appearance or construction, the lamps being placed on the socket or on arms connected to the stem. Some candelabra were furnished with hook arms on which the lamps were suspended by chains. In houses of worship and at shrines, candles were always used in candelabra.

61. Construction.—The important parts of the candelabrum, or standard, as it is commonly called and which



FIG. 55

is the name that will be used here, are the base and stem, though arms and clusters of lights are also supplied. Standards are either set on pedestals and newel posts or are connected directly to the floor or ground, those set in front of houses, monuments, etc. being placed on a stone base. Standards intended for indoor illumination are usually held in position by lighting connections only, whereas standards that are used in the open air must be secured by bolts to the base of porches, stone pedestals, or other suitable bases. Expansion bolts are generally used for holding a standard in position, connections being made through the bottom of the standard and into the base. Standards are always furnished with a globe or lantern.

62. Bronze Standards.—In Fig. 55 is shown a sectional view of a **bronze standard** that may be adapted to either outdoor or indoor illumination. Connections are made at the base, and when the standard is mounted on a stone base, or on a pedestal, the wiring is made through iron pipes. The end of the piping projecting through the base or pedestal is fitted with an insulating joint *a* to which the iron pipe *b* that holds the stem in position is connected.

A spun shell *c* is connected to the pipe above the hickey *d*, and is held in position by the electric body *e*, being

secured to the pipe connected to the hickey, and on which the cluster of lights is arranged. The shell is used to protect the connections and the interior of the standard from rain or water with which the globe or standard may be cleaned. The globe holder *f* is furnished with small holes equally distributed around its circumference, through which the water falling on the globe, or shell, passes off the standard and falls to the ground. Standards should be constructed with a view to making them as nearly water-tight as possible.

63. Cast-Metal Standards.—A cast-metal standard for either interior or exterior illumination is shown in Fig. 56. This standard consists of a base made of three claws, or feet, a stem, a body, or plate, and husks and lamps.

An iron pipe having screw nuts adjusted at the top and bottom is used to hold the stem and body in position. The pipe is run inside the stem and extends through the body, which is fastened by screw-

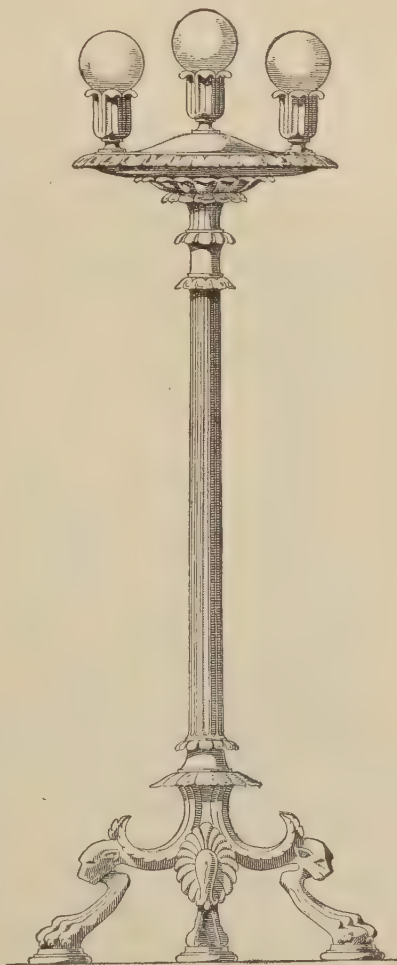


FIG. 56

ing the nut to the top end of the pipe. The outer lights are placed on the body, and the center light is attached to the top of the plate, which is fastened to the body with screws.

This plate must be removed when wiring for the center light, and the wires used should be long enough to permit its removal and allow connections to be made.

64. Newel Light.—In Fig. 57 is shown a **newel light**, which is simply a standard mounted on a newel post. This standard is made of carved wood, and is secured to the post

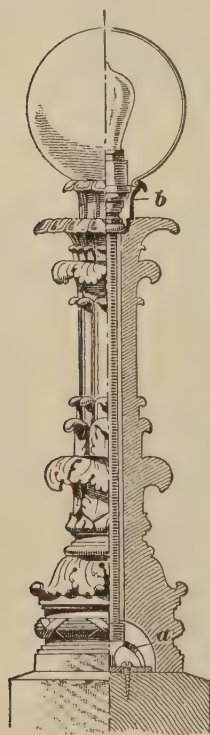


FIG. 57

by wood screws, which are inserted through a tripod *a* in the base. The wiring is done through this tripod, and the iron pipe that holds the stem in position. The fitting *b*, which acts as a globe holder, is made of cast brass, and is screwed to the iron pipe, this connection holding the standard in position. The fitting in this light is made of metal because a wooden fitting would not be strong enough.

65. Other Designs.—In addition to the illustrations given, standards may be arranged in other practicable forms. Thus, gas standards are provided with one or more lights, as, for instance, city lamp posts; or they are provided with a profusion of lights, as when used in churches or auditoriums. When used for interior illumination, gas standards are generally provided with porcelain candles, those in churches being of white porcelain and having the appearance of a straight candle, while the colored porcelain candles of spiral shape are sometimes used in public

halls and private dwellings.

Electric standards may be arranged with a number of lights springing from husks set at four corners of the stem, and having a center illumination of electric lights incased in a ground-glass globe. This globe can be held in position by a cast-metal band secured to the cap or top of the stem, which could be made somewhat like an Ionic capital. It will not

be necessary to give a detailed description of the different designs of any fixture, for new features in the ornamentation and arrangement of lights are brought out each day. But these all conform to the general principles that have been given.

Gas newel lights are constructed with one light or with separate arms set or connected to the stem in a straight line; or, they are made with a cluster of lights arranged on a gas body around a center light, or the center light may be discarded and a cast-metal or spun shell substituted and held in position by a finial knob screwed to a wire connecting to the gas body. Electric newel lights are sometimes provided with a crimson-glass shade resembling the flame of a torch, the illumination being made with one light. A fixture of this description is more ornamental than useful and it illuminates with a truly artistic effect.

66. Combination Lights.—Combination standards and newels must be provided with the extra iron pipe, or conductor, for the wires. If the gas light or lights are placed on top of the stem, they are connected directly to the gas body and the electric lights around the stem are connected to the wires. When gas and electric lights are placed around the stem on the same circle, the combination body must be used, and a cast ball, or sphere, surmounted by a finial knob may be placed in the center; or, the ground-glass globe arrangement of lights previously described may be substituted for the metal sphere. A combination arrangement that permits the use of combination arms may also be applied to standards and newel lights. It should always be borne in mind that standard and newel lights are identical; the latter merely identifies those standards that are mounted on newel posts.

67. Portable Table Lamps.—Table lamps, or portables, are—as their name suggests—fixtures that may be moved about anywhere within a radius equal to the length of the wire connection or gas tubing that may be attached to them.

Fig. 58 illustrates an **electric table lamp** consisting of a base *a*, a gooseneck arm *b*, and a sea-shell shade *c*. The base, which is made of cast metal, has its interior filled with lead so as to give it increased weight. This is very necessary because the end of the gooseneck arm fitted with the shade extends at least 8 inches beyond the center of the base, and if the center of gravity were not thus taken care of, the weight at the end of the arm would cause the fixture

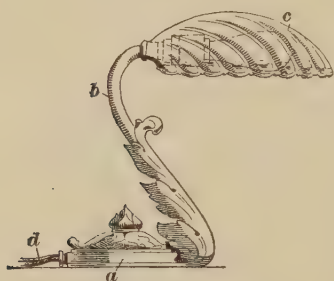


FIG. 58

to topple over. This gooseneck arm is brazed to the base and is furnished with a fitting that supports the shade. The shade is made of translucent glass, which is cast in a mold that gives it the form of a sea shell, and the surface of the shade is then etched, thus giving a satin finish, which produces a soft diffusion of light. As shown at *d*, the wiring is made through a socket at the base. This socket is furnished with a vulcanized-rubber bushing, which serves as an insulator in case the covering is stripped off the wires, and thus prevents the bare wire from touching the metal of the fixture and causing a short circuit, or ground. The portable shown in Fig. 58 has a rigid neck, though flexible necks that permit the light to be arranged at any angle desired are in common use—desk portables, for instance, being almost always made flexible.

68. Gas table lamps, or portables, consist simply of a base, a stem, and a burner, and the base or the stem is fitted with a cock, to which the gas hose is connected. Mica or glass chimneys are used to protect the light, which is reflected on the table by a glass or porcelain shade. The glass shades most commonly used have a green-colored exterior and a white interior

69. Gas Candlesticks.—Ever since the introduction of the candle for lighting purposes, the candlestick has been the

universal candleholder. With the exception of dimensions, the candlestick resembles the standard in all respects, the proportion of the latter to the former being about as 1 is to $2\frac{1}{2}$.

In Fig. 59 is shown a cut-glass candlestick having a base made with an opening in the bottom to provide space for a stiff joint *a* on the gas outlet. The section *b*, called a *break*, interrupts the connection of the glass stem with the base, and a lever cock *c* on the stem controls the supply of gas to the arms, which are made of glass. The twisting and turning of a cock, if placed on a glass arm, would, in a very short time wrench the arm from its fastening, thereby ruining the fixture, which could not be repaired in a satisfactory manner. A cut-glass dish *d* with a fringing of prismatic glass conceals the lever cock, and the arms of the fixture are secured to silver-plated fittings *f*, by plaster of Paris, these fittings being used to connect the arms to a body fitting on the stem. The end fitting *e* on the arms is secured in the same manner as the fitting *f*. A silver-plated spun shell *g* holds the candle *h* in position, and the finial knob is secured to a fitting on the end of the stem.

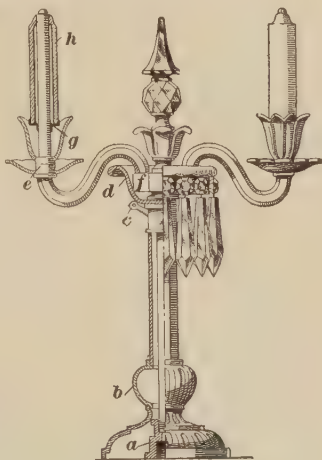


FIG. 59

All metal fittings in this candlestick are silver or nickel plated—a color that blends with the crystalline clearness of the glass. Cut-glass fixtures require a certain delicacy in handling and mounting, and great care must be taken to see that they are perfectly gas-tight—that is, free from any leakage—when they are installed. This is best ascertained by thoroughly testing every part of the fixture in the shop or factory previous to delivery to the purchaser.

70. Electric Candlestick.—A cut-glass candlestick may be made into an electric fixture by fitting it with proper

connections. A like number of arms as in the gas fixture can be supplied, and in addition to providing the glass dish on the stem with a glass fringing, a fringing can be placed at the end of each arm. The best effects of the lamp fringing are obtained by placing the lights so as to divert the illumination downwards. Cut-glass candlesticks can also be provided with combination bodies.

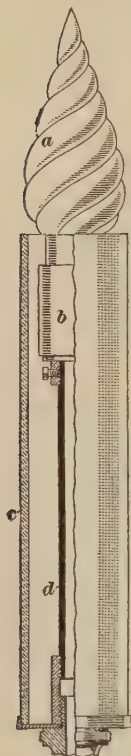


FIG. 60

Electric candle lamps are made principally of transparent and frosted glass. When a soft-colored reflection of light is desired, the candlestick is provided with silk shades, which produce a very artistic effect. Frosted lamps, on candlesticks, also present a very artistic appearance, and burn with a bright, white light. They are placed on mantels or cabinets, and, when illumination rather than ornamentation is desired, are very serviceable. The rough outer surface of these lamps, which resembles a frosted window pane, is produced by placing them in an acid bath.

71. Frosted lamps are made in various forms; some have the exact shape of a candle, some of the standard form given to incandescent lamps, while others are made with elongated spiral curves, representing the flame of a candle. The latter is illustrated in Fig. 60, where the candle flame *a* is connected to a socket *b*, which is placed in a porcelain candle *c* fitted to the arm of the fixture.

The candle tube *d* is screwed to the end fitting on the arm of a fixture, and the socket *b* is screwed to the tube, the thread being soldered so as to get additional strength when making a safe, rigid connection. The connection must be made secure and stiff in order to prevent the socket from turning through handling the fixture, thereby protecting insulation on wires from being worn or cut.

COCKS AND FITTINGS

72. The construction of a **common gas-cock** for a fixture arm is shown in Fig. 61 (*a*), (*b*), and (*c*), and consists of a body and key with a washer and screw. The body *a* is turned out of bar metal, and the key *b* is cast and fitted to the body, the washer *c* and screw *d* being fastened on the key to hold it in position. The body is also drilled and threaded on each end at right angles to the key fitting, and thus provides a passage *e* for the flow of gas. In the under part of the body, which is shown at (*a*), is placed a check to regulate the movement of the key. A hole *e* for the passage of gas is drilled through the key, which is also furnished with a pin *f* that comes in contact with the check on the body when the supply of gas has been turned off. At (*b*) is shown the position of the key when the gas is shut off, and at (*c*) the position when it is burning.

73. A **concealed cock**, which is employed in the construction of lanterns, dining-room and library fixtures, etc., is shown in detail in Fig. 61 (*d*). It is used on arms that occupy the position of combined end fitting and cock, and also on all fixtures where the flow of gas must be converted from a horizontal to a vertical direction while passing through the key. The body of the concealed cock is turned out of bar metal and the key is constructed practically the same as an ordinary gas-cock key, except that the screw holding it in position is drilled as shown at *a* so as to permit the passage of gas through the nozzle *b*. This nozzle is turned out of bar metal, and is screwed to the body as shown.

74. In Fig. 61 (*e*) is shown a **gas swing joint** that is constructed with one cast and one turned-metal fitting. The arm is connected to the turned-metal fitting, and the cast fitting is held in position by a screw and washer the same as a key.

75. A **straight-electric swing joint**, which is constructed with a cast fitting, a turned-metal fitting, and a metal bushing, is shown in Fig. 61 (*f*). The cast fitting is held in

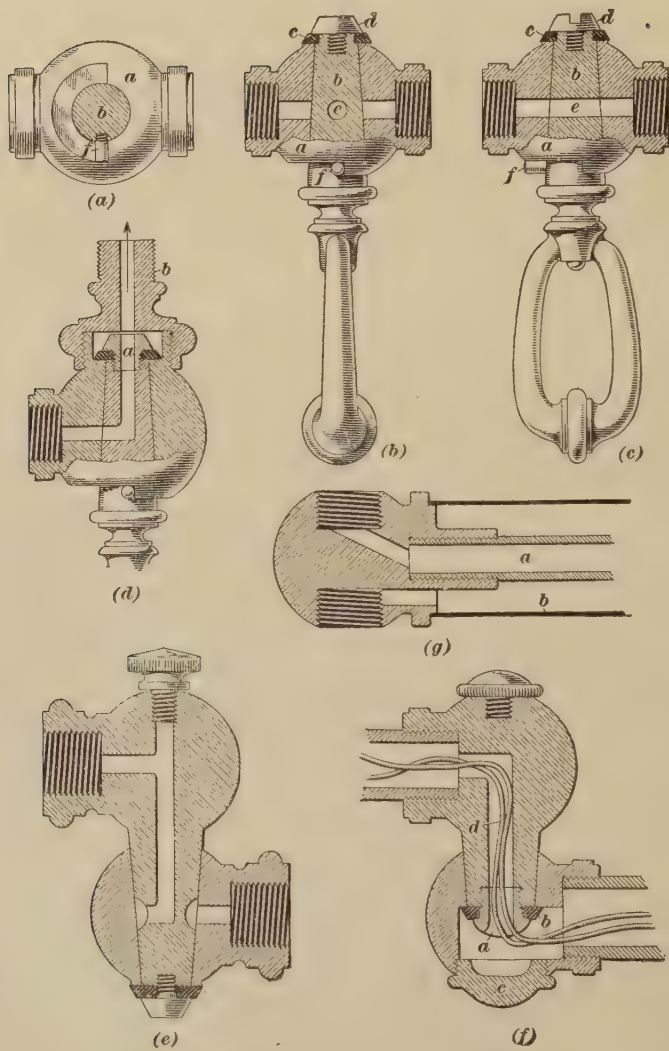


FIG. 61

position by a perforated screw *a* and a washer *b*, and the bushing, or plug, *c* is employed to conceal that part of the fitting which was drilled to allow the screw and washer to be placed inside. Wires are run through this fitting as shown at *d*, and when they are inserted through the fittings, the bushing *c* is unscrewed so as to permit the wires to be pulled taut. After the wiring is completed the bushing is readjusted.

76. A combination end fitting turned out of bar metal is shown in Fig. 61 (*g*). This device combines the practical illumination by gas and electricity through connections on one fitting, the gas passing through the iron pipe *a* and the wires through a covering tube *b*.

77. Gas Igniters.—The object of an igniter is to automatically ignite the gas as soon as it is turned on. This is accomplished in two ways: (1) by allowing a small quantity of gas to burn constantly inside the lamp; and (2) by producing a flame or spark that will automatically ignite the gas when it is turned on. The former is the simpler, cheaper, and more common plan. Igniters are used for lighting gas burners either singly or in groups, and are designed to save the time and labor that would be required to light them by hand.

78. A self-lighting gas burner is shown in Fig. 62.

The key is so made that the gas can never be entirely shut off, and when it is turned to extinguish the light, enough gas is allowed to pass to maintain a small *peep* of flame at the tip of the burner. In order to prevent this flame being extinguished by drafts of air, it is enclosed by a cap, or globe, *g*.

When the burner is in full operation, the globe drops below the flame to the position shown; but when the lever *b* is reversed to shut off the gas, the link *d* raises the globe above the top of the burner, thus shielding the little flame. The

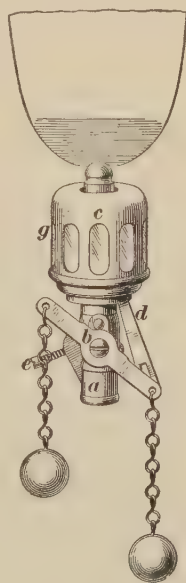


FIG. 62

lower end *a* is a socket, threaded and soldered to fit the ordinary fixture. The fixture to which this burner is attached must be provided with a key, as usual, so that the burner may be entirely turned off if desired.

79. Sun lights, and other large groups or clusters of burners, are usually lighted in a similar manner. When the lights in a cluster are extinguished, one small tip is left burning, and serves to relight the whole group when the gas is again turned on. This burner is commonly called a *pilot light*, and it is supplied with gas by a separate pipe. The supply of gas to all the other burners is controlled by a single cock, so that they may be turned down simultaneously and may be extinguished or promptly relighted whenever desired.

A large number of electric igniting devices use one of two methods: In some, an electric spark is caused to flash through the stream of gas issuing from each burner, thus igniting it; in others, a small piece of platinum wire is heated to incandescence near the tip of each burner, the electric current being turned on after the gas issues from the burners and shut off as soon as the lights appear.

80. Gas Shields.—The space between an ordinary gas burner and the ceiling should be not less than 3 feet. If a smaller distance is unavoidable, the ceiling should be protected by a metal shield to prevent its being scorched or burned. The shield should be separated from the ceiling by a clear space of at least 2 inches, to permit air to circulate between them. Even when a shield is provided, a gas flame should not be permitted at a smaller distance than 18 inches below the ceiling.

If a gas flame is liable to come into accidental contact with inflammable materials, such as curtains or drapery blown by the wind, or hay and straw in stables, etc., it should be provided with a glass globe and enclosed within a stout wire cage at least 10 inches in diameter. The only safe way to determine the proper size of the wire guard is to make tests by holding pieces of cloth or paper against it. If the material can be set on fire, the guard should be made larger.

81. The *discoloration* of *ceilings* may be partly if not wholly remedied by using a *deflector*, or by hanging an ordinary *smoke-bell* over the flame. By spreading out the current, its velocity is checked, the amount of dust that strikes the ceiling within a given area is thus reduced, and the discoloration is lessened.

The only *effectual* method of preventing the discoloration of walls and ceilings in this manner is to intercept the current of hot air rising from each burner and to conduct it to a chimney or ventilating flue by means of a hood suspended over each flame, or set of flames, and suitable pipe connections. This plan is valuable for another reason. Not only are the products of combustion removed from the room, but a considerable amount of air is carried along also, thus aiding ventilation. The hot gas discharging into the ventilating flue raises the temperature therein, and thus increases the draft and improves the operation of the flue.

CONSTRUCTION OF LIGHTING FIXTURES

METHODS OF MANUFACTURE

SHOP AND FOUNDRY WORK

82. **Materials.**—The manufacture of fixtures of all descriptions involves the use of many metals and their alloys, glass, plaster composition, and wood.

Brass is a yellow-colored compound metal consisting of an alloy of copper and from 24 to 37 per cent. of zinc, with very often a small portion of lead and tin being added. Brass is harder than copper, more fusible, and not so good a conductor of heat. Its value in the manufacture of fixtures is due to these qualities.

Bronze is a brown alloy, or mixture, composed of 87 parts of copper and 13 parts of zinc. As it is harder and more fusible than copper itself and oxidizes slowly, even when

the air is moist, it is well adapted for fixtures and assures durability, in addition to which, its appearance is highly ornamental.

While *iron* is used in making fixtures, it is not extensively employed, as it cannot be prevented from oxidizing under the influence of the atmosphere. In spite of all known protectors, such as paints and burning with oil, which clog the pores of the iron, it is impossible to prevent rusting.

Spelter is a mixture of tin and zinc. It was formerly used in making fixtures, but, on account of its brittleness, has been practically discarded. When fixtures made of spelter are once broken, they cannot be easily repaired.

Cut and pressed *glass* are occasionally employed in the manufacture of fixtures.

83. Plaster composition is a mixture used by fixture makers for modeling purposes. The manner of mixing and the constituents employed are almost as numerous as the fixture concerns themselves, and nearly every manufacturing concern possesses its secret recipe, which is jealously guarded. The principal recommendations of plaster composition lie in its cheapness and the fact that, despite the comparatively low cost, excellent effects can be produced with it. One method of making it is to mix together resin, glue, whiting, linseed oil, and cocoanut fiber. A cast of this material is made by placing the mixture in a heated condition into a plaster-of-Paris or wooden mold. This plaster-of-Paris mold can be used for from six to ten casts but the wooden mold may be employed indefinitely.

84. The use of *wood* in the manufacture of fixtures, an innovation introduced by the old Italians, has become quite popular within the past few years because of a desire for antique effects, since the ravages of time can be more easily imitated in wood than in metal or in plaster composition. The worn and time-eaten effects in wood are produced artificially and with such fidelity to detail as to almost defy detection. By the hands of skilled carvers, the wooden fixtures installed in some of the finest dwellings in the

United States have been made to assume an appearance similar to that imparted to the wood by long service.

85. The Mold.—When molten brass or bronze is run into a suitable receptacle, or mold, and allowed to cool and solidify to the resulting object, the term *cast brass* or *cast bronze*, as the case may be, is applied.

A **mold**, therefore, is a receptacle, or matrix, into which molten brass or bronze is poured and given the form desired. The mold is made by impressing in sand one or more cavities representing in outline and general detail the object to be cast. Making the impression in the sand is called *molding*, and it is effected by means of a model, or pattern, which is pressed into the sand in such a manner that, when withdrawn, an imprint of its surface and outline in detail will remain.

86. The Model.—As a preliminary to the work of casting, a **model** that represents the contour and ornamentations of the casting desired is prepared. The general method employed is to first shape the entire fixture in clay, and then cast each part in plaster of Paris, thus obtaining a negative, or mold, of the clay model. This negative is then allowed to dry, and after being lacquered, or oiled, is filled with a thin mixture of plaster of Paris and water, which is run in before the plaster has set. A positive, or plaster-of-Paris, model identically the same as the clay model is thus obtained. It is cut with tools to make it as clear and sharply defined as possible.

This plaster model may be used as a pattern, but if an *applied pattern* is desired, it will be necessary to make a negative of this sharp-cut model in the manner just described. Modeler's wax is then rolled into the form of a plate having a thickness equal to that of the metal desired in the casting, and this wax plate is pressed into the negative, after which the center of the mold is filled with a mixture of plaster of Paris and water. After the plaster has set, the two parts of the plaster mold, consisting of the negative and an imitation positive, are separated, and the wax is removed. The imitation positive is then replaced, and an opening is made

between the two parts of this plaster mold. Melted wax is then run in, a cast of the form required being thus obtained in the wax. After the wax has become cold, the plaster mold is opened, thus disclosing the wax pattern, or model, which has the same thickness as is desired in the metal casting.

At times, models are carved in wood, and the weight of the casting may be approximately determined beforehand by multiplying the weight of the model by 16 if hardwood is used, and by $18\frac{1}{2}$ if soft wood is used. All models are treated to a coating of shellac to prevent them from adhering to the molding sand.

87. Casting.—After the model is completed, a metal cast of the object desired may be made. Casting consists in pouring molten metal into a sand mold. In manufacturing fixtures, the molding box, or *flask*, which contains the molding sand, is always made of iron, and is also provided with openings, called *gates*, that allow the molten metal to enter. This box has two sections, which present the form of an oblong or square frame, but is constructed with only four sides; the openings are either on the ends or the sides. The lower portion, or *drag*, is placed on a board, and sand is put into the frame and packed as tightly as possible with a rammer, or *billet*, resembling a wooden potato masher, but with one end about 4 inches wide and 1 inch thick. When the sand has been firmly packed and leveled to the top of the drag, the pattern is put in, being placed as close as possible to one or more of the openings. The cope, or upper section, is then filled and packed with the sand and placed on top of the drag, being secured by flask pins inserted through ears with which both sections are provided. A layer of charcoal is distributed over the surface of the sand to prevent the sand in the forms from adhering together when the sections of the flask are separated.

When the impression in the sand has been made, the cope is taken off and the pattern removed. Channels from the mold to the openings are then made in the sand, after which

the cope is readjusted and again secured with the flask pins. The flask is then sandwiched between two flat boards, which are tightly held in position by flask clamps, and when the clamps are secured, the boards with the flask are placed on end and the molten metal poured in. When the metal has solidified, it is removed from the mold.

88. A preliminary casting, called the **pattern**, is made from the model, and is used for making impressions for all subsequent castings of the same object. This preliminary cast, or pattern, is always fashioned out of brass of the finest quality, and it is filed and chased, if necessary, before being used for making an impression in the sand. Fine casts are thus obtained, and much time and labor in filing and chasing afterwards are saved.

In making castings in brass or bronze, a small allowance is made for shrinkage, as contraction, or decrease in size, results when the metal run into the sand mold in a molten condition is allowed to cool. The general rule is to allow $\frac{1}{16}$ of the length for shrinkage for brass, and $\frac{1}{32}$ for bronze.

The tendency of the model, or pattern, to cling to the sides of the sand mold and thus destroy its clean, sharp contour is very great; therefore, in order to overcome this tendency, the sides of the mold, or pattern, are always slightly beveled. No general rule of the amount to be allowed for taper can be given, as it varies considerably and is altogether dependent on the character and style of the object to be cast.

89. In casting objects of an elaborate character, that is, those in which scrolls, etc., predominate, precaution must be taken when withdrawing the model to prevent tearing out part of the sand and thus destroying the mold. Outside cores made of fine yellow sand and corresponding to the different parts of the model are used for this purpose. They are separated from one another with thin layers of charcoal, which enable them to be picked out separately, thus affording an opportunity to withdraw the model without injuring the mold. When the model has been withdrawn, the cores are

put back into position uninjured, as the sand used is so adhesive in character that it will allow this to be easily effected. A perfect mold is thus secured, and the molten metal may be poured into the gates of the molding box as before described.

The necessity of using outside cores is obvious when the casting of an object—such, for example, as a clenched hand—is desired. The making of a mold of this character cannot be accomplished in the ordinary manner, as the interstices, or hollows, between the thumb and forefinger and at the outside of the hand near the small finger will tear away part of the mold if an effort is made to withdraw the model. These outside cores, which are their own support, can be taken out separately, and the model may thus be withdrawn without harming the mold, which is again complete when the cores are placed in position.

The method of casting has been described with reference to the making of a pattern, and differs in no respect from the process used in forming duplicates of the pattern. On account of its durability, in the molding room, the brass pattern replaces the models mentioned in the description heretofore given.

MAKING UP THE FIXTURES

90. The departments through which a fixture goes before it is really completed, the processes employed, and the relation of each department in turning out a fixture, will now be briefly described.

The various materials employed in making a fixture are kept on hand in the stockroom, where are also stored the castings that are practically always in demand. Finely chased patterns are placed in a vault in this room, and are kept from coming in contact with one another, as mere contact is sufficient to destroy the effects of the chasing.

91. Cleaning Castings.—From the stockroom, castings are taken to the filing department, where the burrs are removed by an emery wheel and the best steel files. The

emery lathe used to remove the roughness from scrollwork consists of a thin canvas strap coated with powdered emery and two wheels—one large and one small—over which the strap is placed. Power is furnished by a power wheel and belt connected to the lathe. In finishing the scroll, the strap is run in and around each part, the thoroughness with which the work is done depending, of course, on the skill of the operator.

92. Fittings.—After using the lathe, the fixture is taken to the chandelier department where the required fittings are turned, all necessary holes drilled, and threads put on where desired. Cock fittings are made in the cock room, the manufacturing of this special fitting, in fixture making, being considered as a distinct part.

When turned cocks and fittings are required in large quantities, an automatic lathe Monitor is employed. Fixtures are made rapidly and economically with this machine, for after a bar of metal is once set, the lathe will continue its work without the operator's assistance until the bar of metal is used up. One operator may successfully run from four to eight lathes of this type.

93. Bending and Brazing.—The arm makers then take the fixture in charge and do all necessary bending and brazing. In bending an arm with a long sweeping curve, the tubing is filled with sand, and then corked on both ends to prevent the sand from escaping. In more difficult bends, that is, where the sweep of the curve is shorter, the tubing is filled with melted resin, and after the desired bend is obtained, the resin is reheated so that it may be poured from the tubing. For very short bends, the tubing is filled with molten lead, which is removed after the bend is made by again heating and melting it. Filling the tubing in this manner when the bends are to be made prevents kinks and bruises. Ornaments are placed on tubing by arm makers when it is desired. Before brazing any part of a fixture, it must be thoroughly cleaned. It is then placed over a fire, where powdered borax is used to prevent the metal from oxidizing, after which

brazing solder is applied. Brazing solder is a very soft brass, the softness being obtained by increasing the quantity of zinc or spelter in mixing. This solder will therefore melt under the influence of heat more quickly than the metal that is to be brazed. A soft solder instead of spelter solder is sometimes employed for connecting fittings.

94. Shell Spinning.—After bending and brazing, the fixture is consigned to the spinners, who spin all shells required. In spinning, a wooden or metal pattern called a *chuck*, or *block*, corresponding in shape with the shell desired,

TABLE I
THICKNESS AND GAUGE OF METALS

Gauge Number	Thick- ness Inch	Gauge Number	Thick- ness Inch	Gauge Number	Thick- ness Inch	Gauge Number	Thick- ness Inch
5	.182	13	.072	21	.028	29	.0110
6	.162	14	.064	22	.025	30	.0100
7	.144	15	.057	23	.022	31	.0090
8	.128	16	.051	24	.020	32	.0080
9	.114	17	.045	25	.018	33	.0070
10	.102	18	.040	26	.016	34	.0063
11	.091	19	.036	27	.014	35	.0056
12	.081	20	.032	28	.012	36	.0050

is employed. This is fixed on a lathe so that it will revolve rapidly. A circular piece of sheet metal is then fastened to the chuck in such a manner that the metal will spin with the chuck. While the metal is spinning, a pressure is exerted on the metal with a smooth, heavy, steel tool, which rests on a bar, or fulcrum, so as to enable the operator to exert the greatest amount of pressure with the least expenditure of energy. This pressure on the metal causes it to buckle or bend at the edges. The metal is then taken from the chuck, heated, and beaten with a wooden mallet until the surface of the end is smooth. After this, it is again heated,

and while in this state is plunged into cold water; it is then placed on the fire in order to dry quickly, and the operation of pressing it against the side of the block is resumed. Heating and beating the metal in this manner must sometimes be done three or four times before the shell is completed.

When a shell having an opening smaller than the diameter is desired, a *split chuck* made of wood is used. The pieces of this chuck are carefully joined together and so arranged that each piece may be easily removed through the opening when the shell is finished.

95. Material for Shells.—The lowest gauge of metal used in spinning shells is No. 22, and the highest, No. 12. In Table I is given the thickness and gauge of metals employed. •

96. Assembling.—From the spinner, the different parts of the fixture are again taken to the chandelier maker, whose duty is to see that the different fittings are practically constructed to form a perfect fixture. The chandelier maker joins the different fittings together according to the full-size drawing with which he is provided, and drills and taps, or threads, all ornaments, supplies threaded wire where necessary, and constructs the entire fixture, previous to delivering it to the chaser, polisher, plater, etc.

97. Chasing.—The chaser mechanically engraves all fittings to be chased. All castings that have been cored require chasing, as the core leaves traces of the support it gave to the pattern when in the molding flask. In chasing, the fitting is generally laid on a solid hemispherical block made of lead, while steel chisels, varying in size and shape according to the character of the pattern to be chased, are employed. A skilled chaser should possess a sharp eye and a steady hand, for if he should make a mistake in striking the tool—either too light or too heavy—the impression will be easily noticed. Practically all castings of the finest type are chased.

98. Dipping and Polishing.—When chased, the fittings of the fixture are ready for the dipping department. Each fitting is dipped in potash to remove all traces of grease, and then washed in hot water to get rid of any adhering potash. It is next given a bath in nitric acid to burn off any dirt that may still cling to it, washed in cold water to remove traces of the acid, and then placed in a bath composed of one part of nitric acid and two parts of hydrochloric acid, which gives to it a bright finish. After this, the fitting is again washed in cold water, and plunged into hot water, so that on being removed it will dry quickly; the drying process is also hastened by throwing the fitting into sawdust.

If the fixture is to be enameled, the lacquerers apply the enamel in very thin coats, which are allowed to dry after each application. This process is kept up until a clear, smooth surface is obtained.

The different parts of the fixture are now consigned to the polishers, who cut them down with a wheel about 15 inches in diameter. This wheel, or buffer, has layers of cotton cloth placed on it to the thickness of about $1\frac{1}{2}$ inches, to which a substance known as *triple* is applied. The rough surface of the metal is also made smooth by this wheel. A highly polished finish is then given to the metal by a similar cloth wheel on which rouge (ferric oxide) is applied.

If a brass fixture is to be brushed after passing through the hands of the polishers, it is cut down by a brush wheel and white sand, passed through a cyanide wash, immersed in hot water, and then thrown into sawdust to dry, after which it is sent to the lacquering department. If a finish of polished gilt or brass is desired, the fittings pass from the polishers to the plating department where they are immersed in hot water, placed in a cyanide wash, put into cold water, again plunged into hot water, and then thrown into sawdust to dry. When dry, the fittings are brightened by rubbing with a smooth cloth wheel and given to the lacquerers, who apply the desired finish—lacquer, gilt, or polished brass.

A verd-antique finish, which imparts to the fitting a beautiful green color, resembling the oxidation of bronze or brass long exposed to the influences of the atmosphere, is obtained by putting the fittings through the dipping process just described and applying a paint composed of Paris green, powder, varnish, and turpentine. While the paint is still wet, it is wiped off here and there to permit the brass to show through, and a coat of lacquer is applied to preserve the paint. Every manufacturing concern has its own method for obtaining this finish.

If a satin finish is desired, the fixture is taken to the sand-blowing department, where a rough appearance is given to the surface of the metal by blowing sand on it with great force.

99. Plating and Burnishing.—Before a part or the whole of a fixture can be plated with gold, silver, bronze, or nickel, it must first be thoroughly cleansed. This is usually done in the plating room, where the fixture is dipped in potash to remove all traces of the rouge used by the polisher. It is then immersed in hot water to remove the potash, and after placing in a cyanide wash consisting of $\frac{1}{4}$ pound of cyanide of potash dissolved in 1 gallon of water, it is again put into hot water and thrown into sawdust to dry.

Electroplating is a process of coating a metal or metallic surface by exposing it in a bath consisting of a solution of metallic salt, which is decomposed by electrolytic action. A voltaic current is employed for this purpose, and it is supplied by a constant battery, but if plating is to be done on a large scale, a dynamo is used. The vessel in which the metallic salt is placed must be made of some non-conducting material, as, for instance, glass, stoneware, or wood.

In the simple form of plating, the galvanic current is produced in the same vessel in which the plating is done. The object to be plated is attached to a rod connected to the negative pole of the battery, while the metal to be used in plating—gold, silver, etc.—is connected to the positive pole, both the object to be plated and the plating metal being

placed in the vat where the plating is effected. The plating metal exists in the form of a solution of the metallic salt. By passing a current of electricity through the solution the circuit is completed, and the substance of the plating metal attaches itself to the object to be plated. The thickness of the plating is regulated by the length of time it remains in the solution with the electric current active, and the exact weight of the plating on an object may be ascertained by obtaining the difference in weight before and after immersion. After the operation is completed, the plated article is thoroughly washed in hot water, and placed in sawdust to dry.

If it is desired to plate only a section of an object, the part that is to remain unplated is simply covered with paraffin, sealing wax, varnish, copal varnish mixed with jewelers' rouge, engravers' wax, tallow, beeswax, or shellac varnish, all of which can be easily removed after the plating is completed.

An article is sometimes burnished after it is plated. This process consists in exerting great pressure on the plated object with a smooth steel tool that is dipped into a solution containing licorice. Burnishing imparts a high luster to the parts thus treated, making them more prominent than those that are simply polished. After burnishing, the article is passed through a cyanide wash and cleaned in hot water. A gold-plated article should never be lacquered, as it robs the color of the plating of its beauty.

100. Lacquering.—After plating, polishing, and burnishing, the fittings of the fixture are consigned to the lacquering department, where they are carefully wiped so as to remove all dust, grime, etc. They are then placed in a steam-heated closet, and when thoroughly heated, the lacquer is applied. By having the fittings hot, the lacquer distributes itself equally over all parts of the material treated. After the lacquer is applied, the fittings are placed in the steam closet to dry.

The lacquer used for brass or bronze fittings is composed of alcohol, shellac, and seed lac, the latter ingredient being

used to harden the mixture when applied. Lacquering an article serves to keep it from tarnishing.

101. Assembling Fixtures.—The different fittings are next taken to the fitting department, where they are joined together, and iron pipes for the gasway are supplied where necessary. Before the different parts of a fixture are finally fitted together, however, great care must be taken to ascertain that the arms and light connections, stems, arm tubing, bodies, etc., are perfect in every respect, especially proof against leakage. A thorough test must also be made of all arms and connections before attaching them to the body of the fixture, and much time and labor for some future day may thus be saved. After a fixture is completed, it is sometimes very difficult to determine the exact location of a fault, if any exists.

In preparing an electric arm, a small ball chain connected to a steel wire is passed through the tubing, in order to locate any brazing solder or other foreign substance that may be inside of it, after which the electric wires are fastened to the steel wire and pulled through.

The ball chain is used for bent arms as it can be worked through the tubing more readily than the steel wire. The steel wire, however, is used in places where it can be pulled through easily; as, for instance, in arms with a difficult bend that have openings at certain points to allow the fitting or fittings to be brazed to the tubing.

When the electric wires have been pulled through the arms, they are connected with the main, or stem, wire by soldering each connection, after which they are tightly bound with rubber and cloth tape to prevent short-circuiting. Soldering, however, must never be omitted.

In combination arms, the compartment reserved for electricity is wired in the manner just described.

102. The gas compartments in combination arms and gas arms are tested in the following manner: One end of the tubing is closed with the palm of the hand or the thumb and the air is withdrawn from the tubing. The tongue is

then applied, and if it adheres to the opening by force of the vacuum created, the tubing is gas-tight; if the tongue gradually slips away and the tubing will not adhere to it, it must be taken to indicate that there is a leak somewhere.

The exact location of the defect may be determined by plunging the gas arm into water and then blowing through the tubing; any point in the arm from which air bubbles emanate will indicate the exact location of the leak.

After being tested and joined together, the fixture at last passes into the shipping department where the necessary supplies, such as glass, candles, burner, etc., are provided. The fixture is then complete and ready to be installed.

ARCHITECTURAL DESIGN

INTRODUCTION

1. Architectural design does not consist of the introduction of standard conventional forms of a historic character into a building composition, but of the disposition and arrangement of masses of light and shade—wall openings and wall solids—and the proportioning of parts so as to establish a feeling of balance and harmony and to please the senses. Mechanical design, on the contrary, consists of the proportioning of parts and materials to serve some useful purpose and to satisfy the demands of strength.

The thickness of a stone pier, the depth of a lintel, or beam, between two piers, or the proportioning of a wall according to its height, is a matter of mechanical design, but the grouping of the piers or the introduction of molded lines so as to divide the surface of the walls into panels of varying proportions for the sake of appearance, is a matter of architectural design. Generally speaking, architectural design consists of the artistic grouping of the structural necessities and the emphasis of these necessities by ornament, but scientific construction must always be the first consideration.

2. A building must be planned first to suit its purpose exactly. Every detail must be proportioned to every other detail in order that there may be no cramping for space in one part and superfluous space in another. Consideration must always be given to every utilitarian element that enters into the purpose of each equal subdivision of the plan; therefore, the most important consideration in architectural planning is *utility*.

In order that the building itself may present fully the utilitarian advantages expressed in the plan, the construction must be perfect, and the methods of construction should be considered and worked out with the planning of the building and not left until the actual building operations are commenced.

The construction, from an architectural standpoint, should present a satisfactory appearance of strength to the eye, and the strengthening details should be so distributed as to lend variety to the structure itself. The proportioning of structural parts will depend on the material used, and the character of the material should therefore never be disguised, but always worked to show up to its own advantage and express architecturally its own strength and purpose.

3. For that reason, a design should always be worked out mentally before any attempt is made to lay it out on paper. If the design be for a house, then the whole house, including its arrangement of rooms, its general proportions, its color, and its outline against the sky, should be pictured mentally. This mental picture need not be exact, but it should give a definite basis on which the designer may work.

When a designer starts the design of a tomb modeled after a classic temple, his mind pictures a rectangular building with a low, gabled roof or something similar. When he designs a Gothic church, his mind pictures a crucial ground plan, buttressed walls, pinnacled gables, and towering spires.

However, tombs may be built in other styles, and churches need not be Gothic. Residences existed in all ages, and there is such a variety of form and device that can enter into their composition that the designer is likely to become reckless with such a wealth of material to choose from, and will work out his design independent of any fixed idea, trusting to the suggestions that occur to him as he proceeds with the work. This is all wrong, and only by frequent experiments and alterations, both in plan and in elevation, can the ideal be realized and perfection and proportion of form be brought about in the design for any individual purpose.

DESIGN AND COMPOSITION

ELEMENTS OF DESIGN

4. A design for any purpose will always represent one of two forms: that of a *surface* or that of a *solid*. In the one case, there is more or less of a given space to fill with appropriate and pleasing forms that are suited to their place and purpose. In the other, there are three or more sides to be considered separately or together, according to their purpose in enclosing the solid, and frequently a further consideration that exists within the solid itself, such as rooms and their relations.

As a surface design is nearly always viewed as a surface and is not materially affected by the point of view, it can be designed simply as a surface. A solid, however, materially changes in appearance according to its position above or below, or to the right or to the left, of the eye, as in these different positions its surfaces vary in proportion to each other and present varying appearances; hence, a solid should be designed in perspective.

5. **Surface Designs.**—The first subject to be considered is a surface design in which the designer is limited by given structural lines that are unalterable in general position, but may be changed somewhat in form to suit the esthetic ideas. In Fig. 1 are shown four combinations of straight lines. In (a) is a simple zigzag, or reversible, pattern; and in (b), a simple quarry, or series of squares. In (c), the interlaced lines form diamonds, or lozenge shapes, and at (d) are shown equilateral triangles. Let it be assumed that these lines are to form the structural elements of a design such as a leaded-glass window, an iron grille, or some other subject, and that it is desired to change the straight lines to curves, so as to

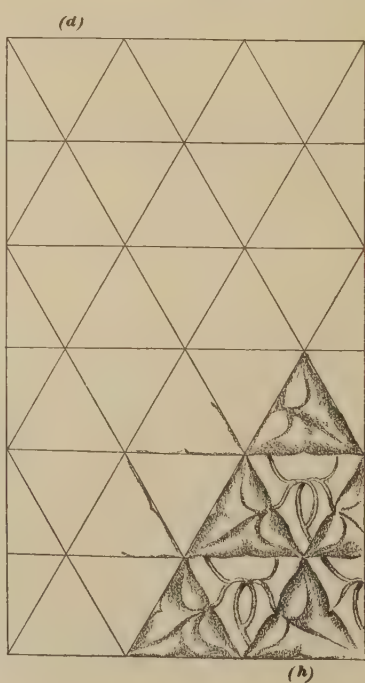
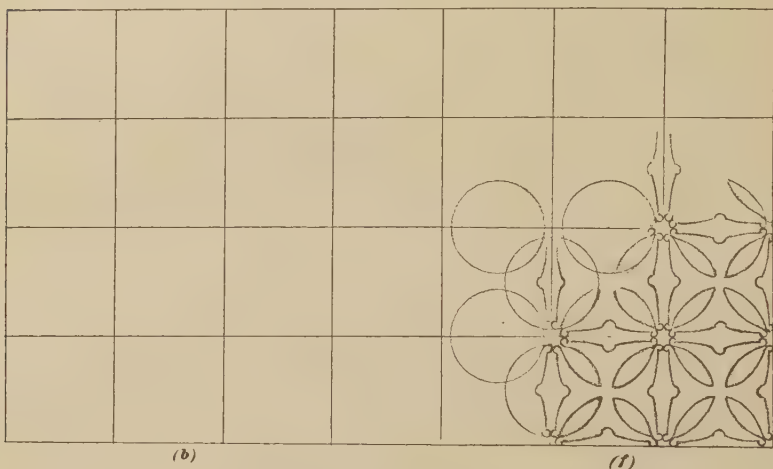
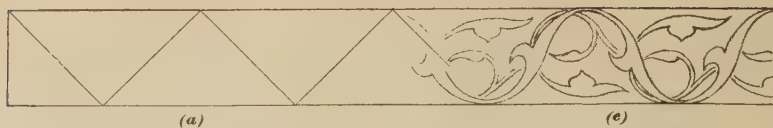
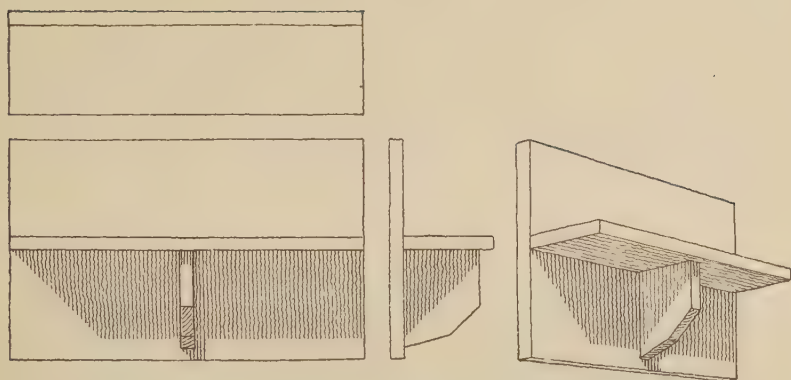
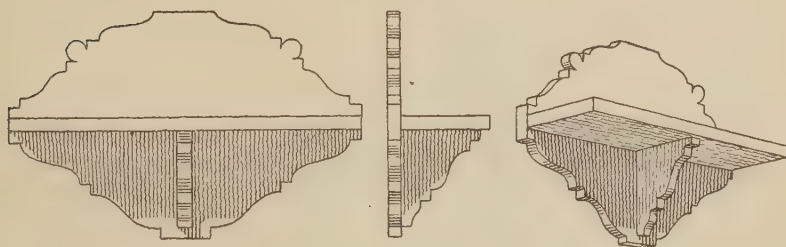


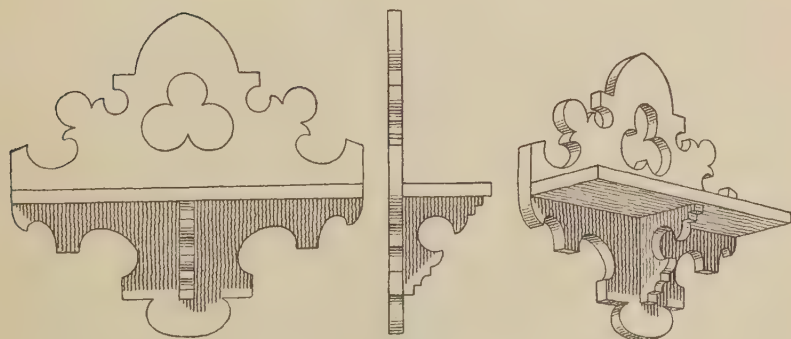
FIG. 1



(a)



(b)



(c)

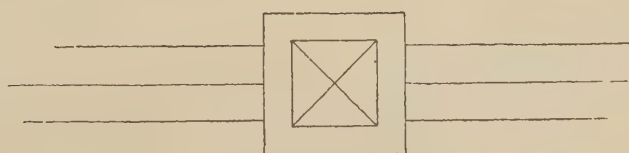
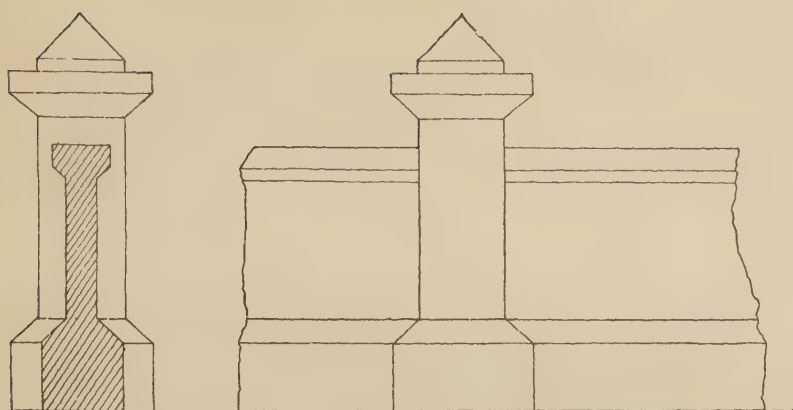
FIG. 2

make the proportions pleasing, introducing other lines where necessary to carry out the idea of the design, but exercising great care not to disturb the structural character of the given lines. This character may be retained both by changing the straight lines to curves and by making a variation of light and shade values between certain surfaces that are so bounded. Several results that can be obtained under these restrictions are shown at (*e*), (*f*), (*g*), and (*h*), which are designs worked out on the lines.

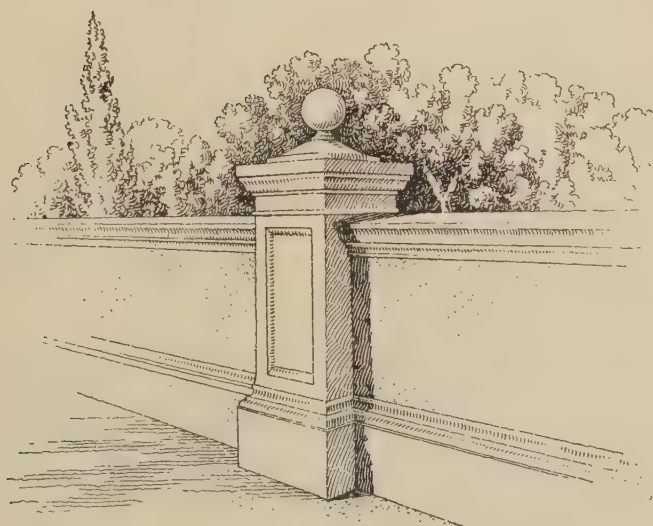
6. Where an object is composed of several surfaces that are introduced purely for purposes of utility, it may be made ornamental by giving these surfaces a pleasing outline. But care should be taken that the structural lines are not lost nor the utilitarian purpose of the object impaired by the treatment.

In Fig. 2 (*a*) are shown the plan, elevation, and perspective views of a wooden bracket with a backboard and shelf. This bracket consists simply of three pieces of 1-inch plank put together in the manner shown. So far as its utilitarian purpose is concerned, the shelf is very satisfactory and will carry all that was intended for it; but if curves are substituted for the straight lines, wholly or in part, the entire character of the bracket may be changed, and without losing in the slightest degree any of its utilitarian value, it becomes pleasing to look on and an ornament in itself. A comparison of (*a*), (*b*), and (*c*) will show how, without detracting in any way from the purpose of utility, and without adding any outside detail or other device, the elements constituting utility and beauty can all be combined in one design.

The curves in Fig. 2 (*b*) that are substituted for the straight lines in (*a*) must be considered carefully, or their lack of proportion will render the bracket uglier than the simple utilitarian device. The curves characteristic of the classic moldings are used in (*b*), and where necessary they are separated by straight lines in order to give them emphasis, while in (*c*), the curves are Gothic.



(a)



(b)

FIG. 3

7. While this principle of design is similar to that of the problem shown in Fig. 1, it partakes of a different character, inasmuch as the surfaces are in different positions and therefore bear the same relation to each other as the bounding surfaces of a solid. Neither are the surfaces subdivided in this case as they are in Fig. 1; they are simply outlined with a pleasing contour. There is an unlimited variety in the combination of curves that can be used in solving this problem, but there should be a definite and harmonious relation between the curves that are used to outline the bracket, the shelf, and the backboard.

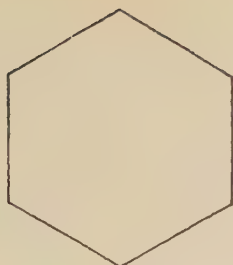
Outline design is of importance in its application to vases and vessels of a similar character, and these are usually identical in elevation, no matter from what point they are viewed.

8. **Design of a Solid.**—The conversion of the simple utilitarian bracket shown in Fig. 2 (*a*) into the ornamental devices shown in (*b*) and (*c*) can be extended to objects of any proportion and size. In the bracket, as said before, it was simply a case of design and an arrangement of surfaces; but in the solid, it becomes a problem of the detailing of surfaces whose interest must be enhanced by subdivision and whose outline is unalterable.

In Fig. 3 (*a*) are shown a plan, front elevation, and end elevation of a low parapet wall interrupted by a post. It is apparent that this is a simple utilitarian construction consisting of a simple geometrical form for the post, from which extend perfectly flat walls with coping and base. The coping is beveled on its under side at an angle of 45° , both on the wall itself and on the post, and the base that extends around the post along the wall is similarly beveled, but no attempt is made to indicate the existence of moldings. Now, if curved lines are substituted for the straight lines of the inclined surfaces just referred to, and these are molded in harmony with rules of classic composition, the utilitarian construction will be converted into an ornamental construction, Fig. 3 (*b*), that is just as suitable to its purpose in every way, but much more pleasing to the eye.



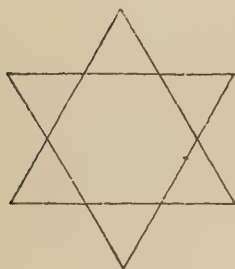
(a)



(b)



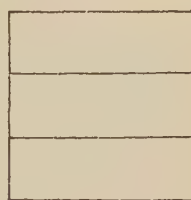
(c)



(d)



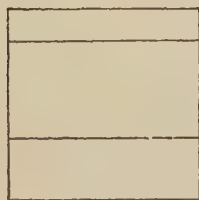
(e)



(f)



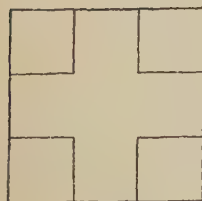
(g)



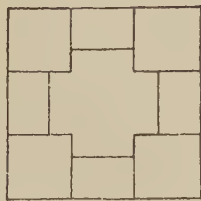
(h)



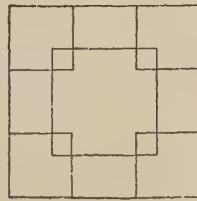
(i)



(j)



(k)



(l)

FIG. 4

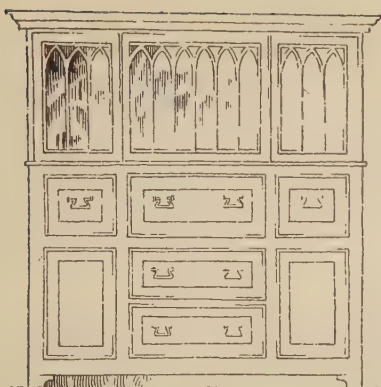
ELEMENTS OF COMPOSITION

9. **Composition**, whether it be in painting or in architecture, consists in arranging and grouping lines and masses so that in themselves they will present a pleasing relation to one another, regardless of what they represent. In Fig. 4 (*a*) are shown six lines of equal length that bear no relation one to another and are therefore meaningless; but grouped as shown in (*b*) to (*d*), they express a uniform idea from which no one of them could be removed without leaving a feeling of incompleteness. This composite arrangement of lines that forms a complete idea is termed **unity**, inasmuch as the lines no longer form separate elements, but are the units of a design.

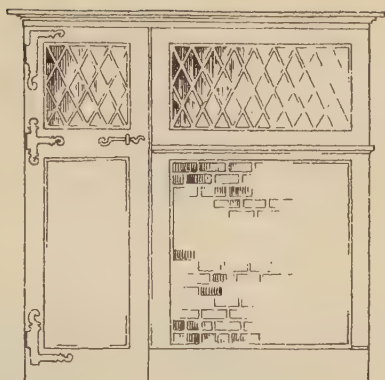
10. Unlimited combinations of lines can be made to express unity in different forms, but some of them will be more pleasing than others. For instance, the six lines just mentioned are united to form a square with four equal interior squares in (*e*), three equal rectangles in (*f*), and two rectangles and two unequal squares in (*g*). Of the last three forms, (*e*) and (*f*) are the least interesting, as they present no variety; and while (*g*) is merely a variation of (*e*), and (*h*) a variation of (*f*), these simple variations serve to render the forms more interesting while still preserving the feeling of unity. By changing the lengths of the lines and introducing more of them, an infinite variety of designs can be produced, all composed of squares and rectangles and all based on one general arrangement.

In (*i*) is shown a checker arrangement of eight lines that is interesting in itself, but becomes more pleasing with the removal of the central square, as shown in (*j*). By replacing the sides of the central square nearer the outside square, the design shown in (*k*) is produced, and this suggests a continuation to the form shown in (*l*).

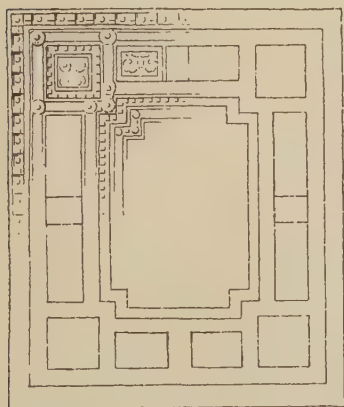
11. The application of this idea architecturally is shown in Fig. 5, where at (*a*), the structural lines of the cabinet are derived from conditions similar to the ones shown in



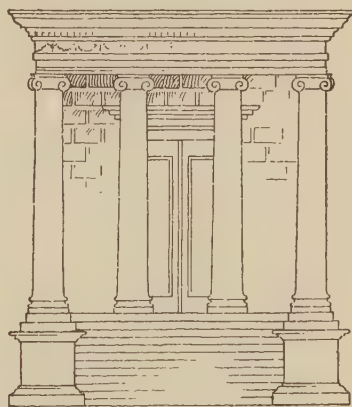
(a)



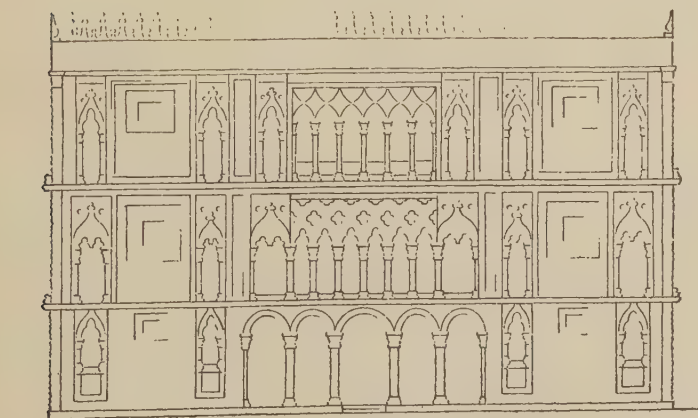
(b)



(c)



(d)



(e)

Fig. 4 (*i*), but with variations to render the subdivision more interesting. The door and window in Fig. 5 (*b*) is precisely the same as the composition shown in Fig. 4 (*g*), the structural lines being emphasized to bring out the effect. The sketch of the ceiling in the Farnese Palace, Fig. 5 (*c*), is practically the same in structural lines as the design shown in Fig. 4 (*k*).

With a given space to divide up by means of structural lines, it is simple at first to work out a design in a simple manner, as in Fig. 4 (*k*), and when several arrangements have been tried, to work up the structural details, as in Fig. 5 (*c*). It is also excellent practice to take existing buildings and reduce their structural lines to simple composition sketches, as shown in Fig. 5 (*d*), which is a sketch of the line grouping of the temple of Fortuna Virilis, and Fig. 5 (*e*), which is the façade of a Venetian Palace.

Sketching the structural elements in this way gives practice not only in the analysis of existing designs, but at the same time trains the eye to appreciate the true value of each line in a composition. Draw an elevation with as few lines as possible to express the design, and these lines will be found to be the structural elements on which the design is based and around which all other elements are to be subordinated. In any composition, whether it be a picture or a building, it is more difficult to determine what to leave out than what to put in. Too much detail will detract from the principal structural elements; too little will render the composition somewhat bare.

EXERCISE I

1. **Sheet I.**—Make four designs of surface treatment based on the structural lines shown in Fig. 1, the zigzag to be about 1 inch wide and 8 inches long, and the other three to be about 2 inches wide by 8 inches long. The designs should be arranged to fit on a sheet 9 in. $\times$ 12 in. The structural lines need not be shown, but the finished pattern should be designed so that there will be no doubt as to the base on which it was worked.

2. **Sheet II.**—Make two designs for a wall bracket similar to those shown in Fig. 2, one to be composed of classic curves and the

other to make use of Gothic details. Each design is to consist of a plan, two elevations, and a perspective view, and all to be included on one sheet 9 in. $\times$ 12 in., with a $\frac{1}{2}$ -inch border line.

3. **Sheet III.**—Make twelve line-composition sketches to fill a space of 8 in. $\times$ 11 in. on a 9" $\times$ 12" sheet, similar to the examples shown in Fig. 4 (*j*), (*k*), and (*l*). Each sketch to be about $2\frac{1}{4}$ in. $\times$ $2\frac{1}{2}$ in.

4. **Sheet IV.**—Make a sheet of composition sketches of the structural lines of four of the following buildings: Maison Carrée, Fig. 74, *History of Architecture and Ornament*, Part 1; Arch of Constantine, Fig. 85, *History of Architecture and Ornament*, Part 1; Church of San Michele, Fig. 31, *History of Architecture and Ornament*, Part 2; St. George's Chapel, Fig. 82, *History of Architecture and Ornament*, Part 2; House of Desdemona, Fig. 65, *History of Architecture and Ornament*, Part 3; City Gate at Munich, Fig. 82, *History of Architecture and Ornament*, Part 4; White House, Fig. 94, *History of Architecture and Ornament*, Part 4.

COMPOSITION IN ARCHITECTURE

UNITY

12. Composition in architecture deals with the outlining of the general mass of the building and the grouping of the parts, so as to make it appear as one mass and give it an expression of **unity**. This expression of unity can always be attained by a grouping of the details, the larger details being first considered, and the secondary details being grouped throughout the larger ones, precisely as was done with the lines of Fig. 1.

REPETITION AND CONTINUITY

13. There are occasions, however, as in the colonnade of a building or in the dormers of a roof, where the details cannot be so grouped as to produce unity. In a case of this kind, no attempt at unity should be made, but an effort should be made to produce the effect of **repetition**, of which the eye will not tire as soon as it recognizes the fact. A grouping to produce repetition must be such that in

looking at the design the eye will not wander from one part to another, but will be arrested by a single central feature or others around it, on which all other features seem to depend. All the elements of a building should then be treated according to their importance, so as to come in a general group, and in order to do this, they must be subdivided so as to become details of the mass.

14. While unity of the mass is essential to all composition, it does not prevent the introduction of many similar subordinate details, each of which may be considered as a minor unit in itself. All the designs shown in Fig. 1 are composed of a number of minor units that are repeated to unite and form the whole pattern. Therefore, repetition is an element of design that can be depended on to lend interest to subordinate parts.

15. Where repetition is thus introduced, the design should be terminated at each end with some important detail; in order to prevent the feeling of **continuity**, or **unlimited repetition**, which is very unsatisfactory in architectural composition. This is prevented in the example shown in Fig. 6 by the tower masses at each end, between which the dormers are repeated, but in the Château Josselin, Fig. 7, there is no terminating mass, and the building consequently has an unfinished appearance, as if something more was to be added.

The only condition wherein continuity is acceptable in an architectural composition is around an interior court where a colonnade can be carried around all four sides, as in Fig. 6, *History of Architecture and Ornament*, Part 4. An interior colonnade should always be included between flanking masses (see Fig. 43, *History of Architecture and Ornament*, Part 4) or around the building as a peristyle, as in the Greek temples.

ALTERNATION

16. **Alternation** consists in the repetition of two or more details alternately, as in the second story of the Farnese Palace, Fig. 4, *History of Architecture and Orna-*

ment, Part 4, where the pointed pediment and the curved pediment are used alternately over the windows. In alternation, it is important that an odd number of details be used, so that both ends may be alike; otherwise, the feeling of continuity will be even more marked than in simple repetition.



FIG. 6

CONTRAST

17. **Contrast** consists in the grouping of details that are totally unlike either in form or in size. It is introduced in architectural composition to give prominence to the principal detail, in order to avoid a division of interest, as will be discussed under the heading Grouping.

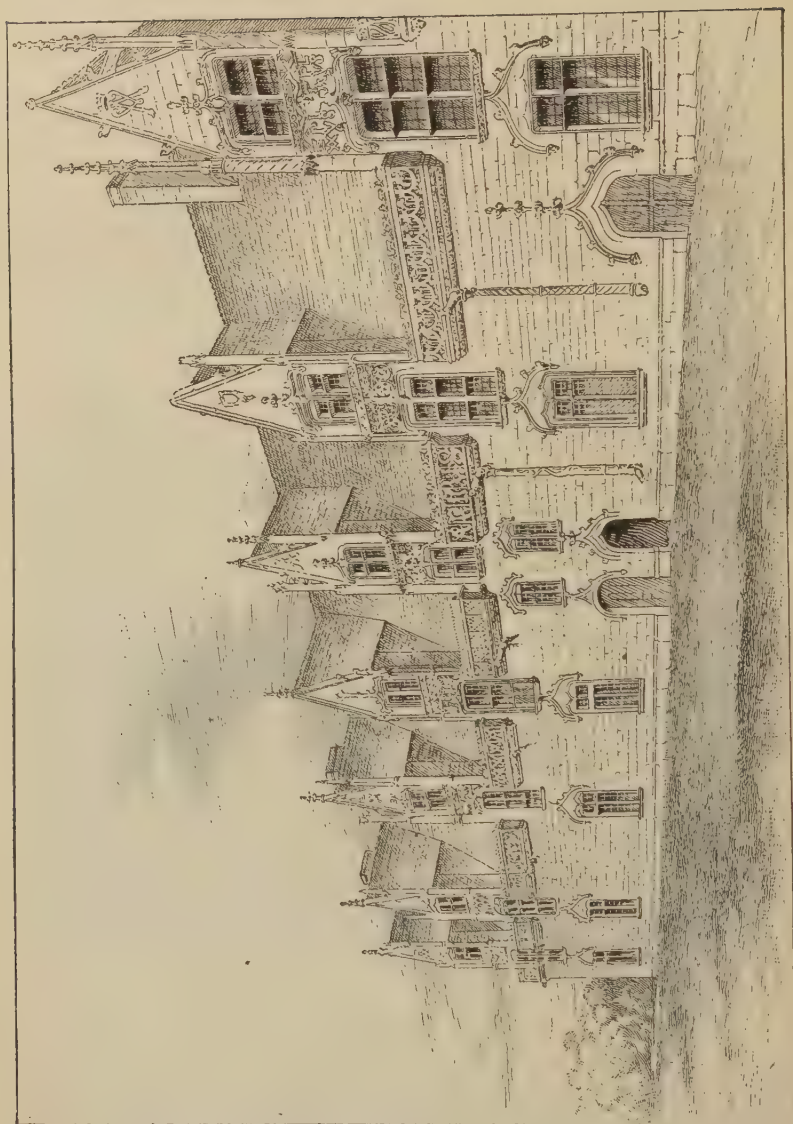


FIG. 7

GROUPING

18. In arranging architectural details to secure the effect of unity, there are three groupings that are entirely satisfactory.

A *single mass* always looks well when surrounded by subordinate details that do not distract the attention from the central feature, as in the Market at Haarlem, Fig. 59, *History of Architecture and Ornament*, Part 4. Other examples of this individuality of mass are to be found in the pyramids of Egypt, the Parthenon at Athens, and the Hôtel des Invalides at Paris.

A group of *two similar masses* is satisfactory if there is nothing inharmonious between them, as can be seen in the elevation of the Cathedral of Notre Dame, Fig. 1, *History of Architecture and Ornament*, Part 3. The two masses must be similar, however, although not necessarily identical. A square tower and a spire or a dome are too unlike to be grouped as a pair in one composition. Beautiful as the tower of the Antwerp Cathedral may be in itself, the entire composition is unsatisfactory, owing to the dissimilarity of the neighboring mass. (See Fig. 29, *History of Architecture and Ornament*, Part 3.)

A group of *three things* can be made to look well in composition, as in the Church du Béguinage, Fig. 58, *History of Architecture and Ornament*, Part 4, if the group does not consist of details equal in importance or identical in form and size. Three minor details can be grouped together, as three windows or three arches, but three domes, three gables, three spires, or three wings in a building, all of practically the same value, cannot be made to harmonize.

19. When three such important details are to be grouped, one of the three must be either emphasized, so as to present a single feature dominating the other two, or subordinated, so as to form a group of two connected by the third. The members of a group of three need not be of exactly the same form, although they should be sufficiently so to asso-

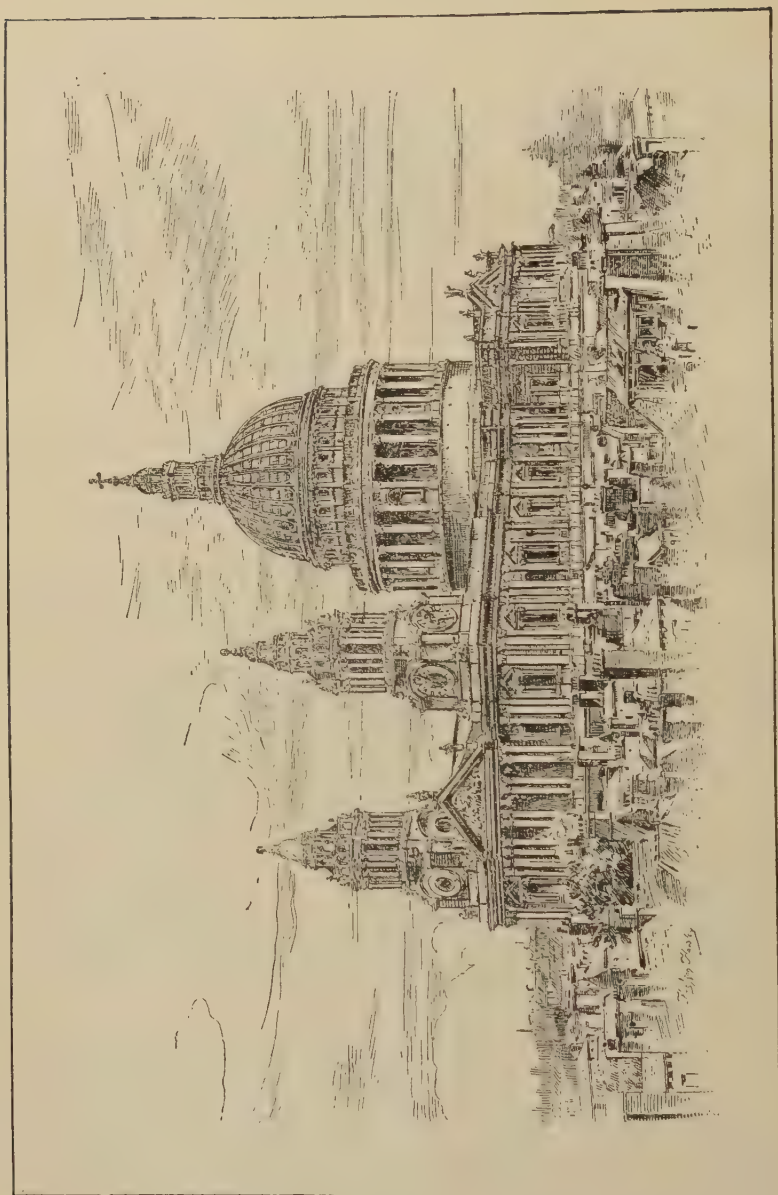


FIG. 8

ciate themselves with the same idea. The towers and the dome of St. Paul's Cathedral, Fig. 8, are unlike in form, but they are all associated as roof details and unite against the sky to establish a principal feature. The dome is attended by two subordinate features—the towers. In the front view of the building, however, the towers become the leading



FIG. 9

features, and they form a group of two with the pedimented portico between, as shown in Fig. 9. It is evident, therefore, that the design of St. Paul's Cathedral presents different problems, according to the point from which it is viewed.

20. Single Mass and Group of Two Masses.—For the purpose of practically demonstrating the foregoing principles, the illustrations shown in Fig. 10 will be considered. In (a) is shown a single mass constituting a group of *one*,

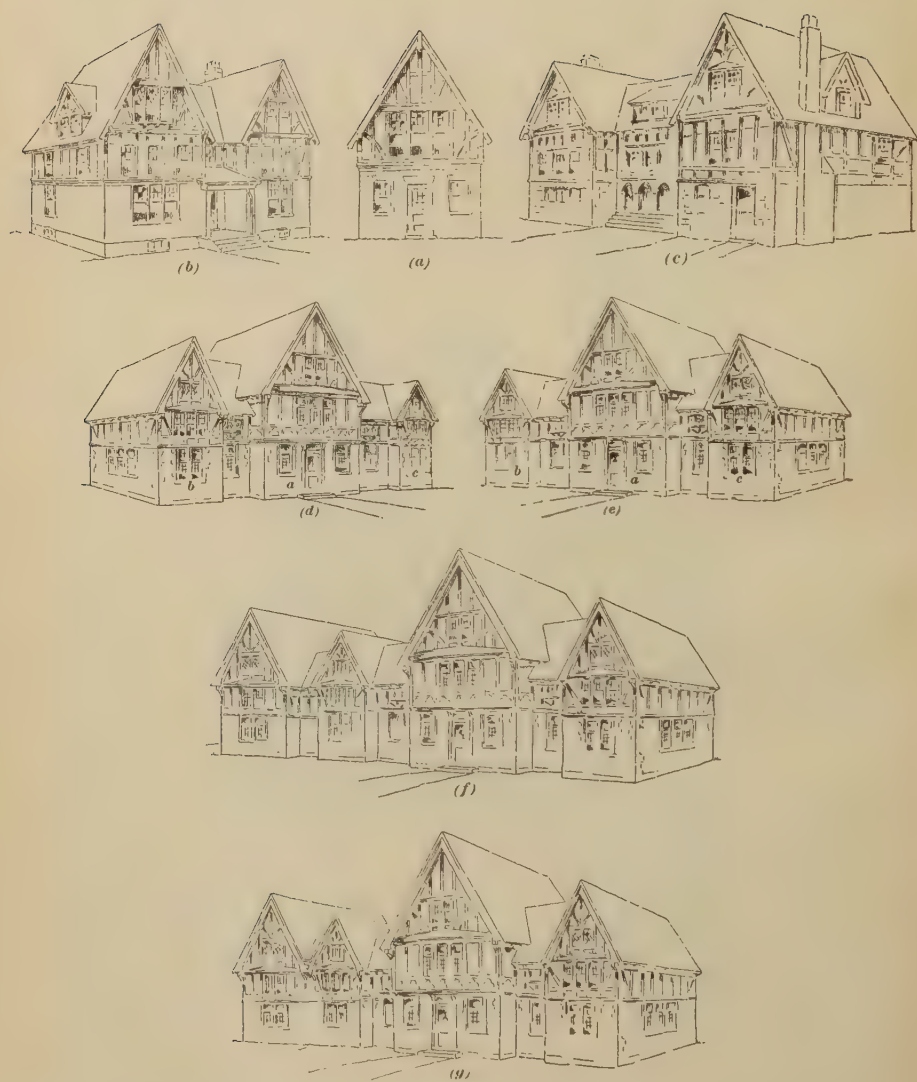


FIG. 10

and in (*b*) there are two masses of unequal importance connected by a detail too insignificant to distract the attention in the slightest degree. The large mass undoubtedly arrests the attention at first, but the smaller one soon unites itself in the idea and there is at once the desired feeling of unity.

In (*c*) is shown a group of two almost identical objects with a connecting detail. Here, however, it will be observed that this connecting detail is of more importance than in the preceding case, and that the masses are more separated. Where the masses are unequal, particularly if only slightly so, it is desirable to bring them close together in order to emphasize this inequality; but where they are intended to be alike, it is well to separate them, so as to make them appear as a group of two and at the same time subdue any slight inequality of detail that might exist in them.

21. Group of Three Masses.—In arranging a group of three masses, the rules to be followed are the same as before, but a satisfactory disposition of the principal and subordinate parts becomes more difficult to accomplish. In Fig. 10 (*d*) is shown a group of three unequal masses, the largest one being in the center and the others arranged on each side. This is the most logical arrangement for such a group, and from a certain point of view, the lesser object is near the observer, the smallest one being in the distance, where its apparent size is decreased, and the contrast between the three masses becomes at once evident. However, suppose that the grouping be studied from the opposite direction as in (*e*). Then the smallest mass is nearest the observer, and the second one in the extreme distance appears about the same in importance as the third. Closer observation proves this to be false, and as a result the composition lacks repose. To obviate this, the grouping should be so arranged that masses *a* and *c* are close together and contrast with each other, and that mass *b* is moved farther away so that it will not become associated with *c*.

If circumstances are such that *a* and *b* cannot be separated or that *a* and *c* cannot be brought close together, the only solution is to emphasize the unsymmetrical arrangement. This can be done by uniting *a* and *b* so as to make them appear as one mass and separating *c* so as to form the secondary element in a group of two. The grouping of the masses relative to each other depends entirely on the point of view, and for that reason it is always desirable in architectural design to work out the preliminary studies in perspective before any attempt is made to draw the scale elevation.

22. Group of Four or More Masses.—As shown in Fig. 10 (*f*), a group of four or more separate masses can never be rendered in a satisfactory manner. Where there are more than three principal masses in a composition, one of them should be subordinated so as to divide the composition into three principal groups or details, as in (*g*). Here, four principal objects badly grouped, causing the entire composition to be unsatisfactory and out of repose, have been altered to form a group of three. In observing the design shown in (*f*), the eye wanders from one part of the composition to another and tires itself without finding a satisfactory place to rest; in observing that in (*g*), however, the eye is taken at once to the central mass, to which the others are subordinate.

There are a number of different arrangements that might be applied to this composition to overcome these eccentricities. The members of the masses might be spaced differently, as this arrangement of them, at what appears to be an equal distance apart, is monotonous in the extreme, but a grouping such as shown in (*g*) improves matters, and there is not sufficient change in the arrangement to make any decided alteration in the plan necessary. The masses have been arranged so as to appear as a group of three; the two smallest ones being united in one mass with little or no connecting details. Then the first and second have been separated and the whole group treated as in (*e*).

All of this can and should be accomplished without any feeling of forcing things into place. Architectural composition demands study in order to effect the simplest arrangement possible and thus secure the most satisfactory results. A careful study and comparison of the most prominent buildings in history will show that simplicity of plan and ingenuity in the grouping of the masses of their composition are their characteristic features.

23. Grouping of Dissimilar Masses.—Two dissimilar details of equal mass or importance, as in Fig. 11 (*a*), cannot be grouped, nor can three equal but dissimilar masses, as in (*b*), be satisfactorily united. The two details shown in (*a*) are equal in importance, but they are unlike in form. They do not repose well together, as there is always an uncertain feeling as to which should dominate the other, and while the arrangement shown in (*c*) is an improvement, it is still decidedly unsatisfactory. Both pavilions are equal in mass and similar in form, but they are so unlike in detail that their dissimilarity is pronounced. The mansard roof on the left pavilion does not establish repose, as it seems out of keeping with the pointed window heads and pinnacled buttresses, with which the pyramidal roof was more in harmony. Therefore, this design should be still further changed by having the openings and minor details more alike in form, while a contrast could be maintained in the treatment of the connecting link.

Under such conditions as this, the designer must resort to the union of the two dissimilar objects into one, otherwise he leaves two centers of interest in his arrangement, and has on his hands what might be termed a *dual composition*; that is, an arrangement literally consisting of two separate compositions. This is often seen in a building where a pair of arches has the inner abutments resting on a single column and the outer abutments supported on heavy masonry walls.

24. It has already been stated that in a group of three masses the central one should be the strongest and most important, and at the same time different in form from the



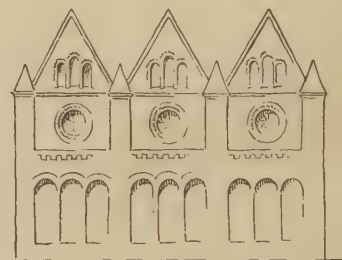
(a)



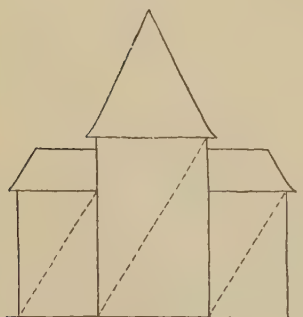
(b)



(c)



(d)

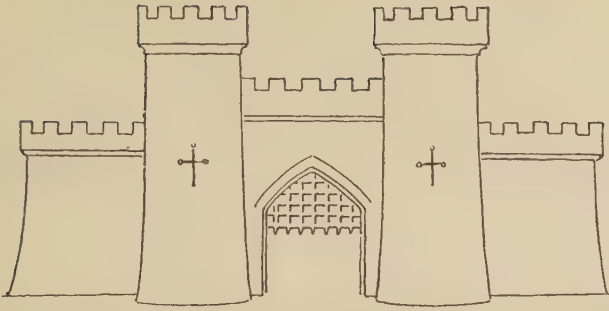


(e)



(f)

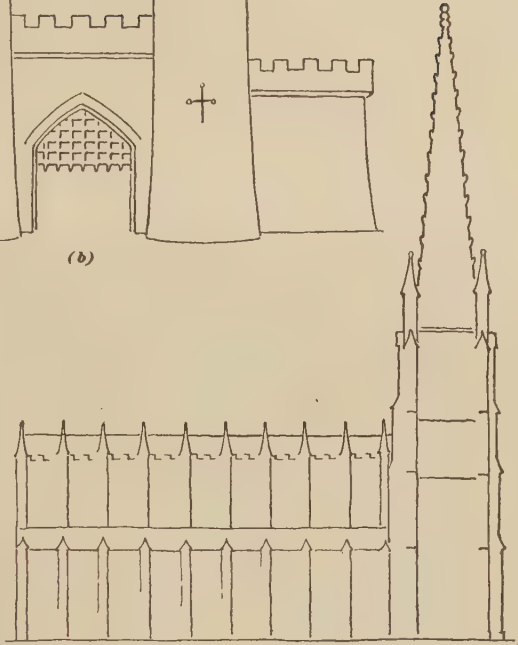
FIG. 11



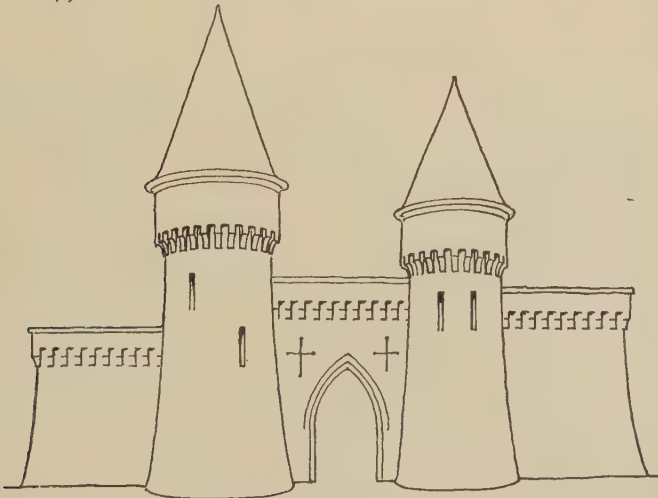
(b)



(c)



(a)



(d)

other two; or, the central mass may be minimized by emphasizing the flanking masses and treating the composition as a group of two. This cannot be done with the two arches just referred to, however, unless they are united under a single arch, as was occasionally done in the Venetian palaces [see Fig. 26 (a), *History of Architecture and Ornament*, Part 4].

The three equal, but dissimilar, masses shown in Fig. 11 (b) do not harmonize much better than the two shown in (a), and if the composition were altered to include three gables, as at (d), the design would still be unsatisfactory, as it consists of three equal and similar masses. Therefore, there remains only one of two things to do—either increase the importance of the central mass, as in (f), or treat the two outside gables as auxiliary masses, as explained in the next article.

25. Auxiliary Masses.—There are occasions in architectural design when it is hard to decide whether a part of the building is a mass or a principal detail. In the Hôtel des Invalides, Fig. 44, *History of Architecture and Ornament*, Part 4, there is no doubt about the dome being the principal mass, but the side wings seem to belong to mass also, and can scarcely be called details. Therefore, the wings become **auxiliary masses** [see Fig. 11 (e)], and are necessary to complete and emphasize the importance of the main mass itself. A similar composition exists in St. George's Chapel, Fig. 82, *History of Architecture and Ornament*, Part 2.

An auxiliary mass may be symmetrical or otherwise, as the case may require. It may form part of a composition consisting of one mass and an auxiliary, as in Trinity Church, New York, Fig. 12 (a); it may be duplicated each side of a central detail, as in the Hôtel des Invalides already referred to; or it may be attached to each of the masses in a composition of two, as shown in Fig. 12 (b). The auxiliary mass need not necessarily be low, as tall auxiliaries, Fig. 12 (c), are quite as common.

The auxiliaries in a triple group should be symmetrical when the triple masses are symmetrical; but when the out-

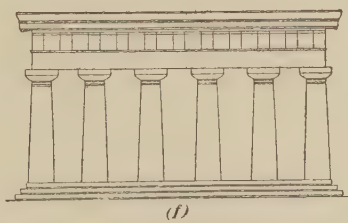
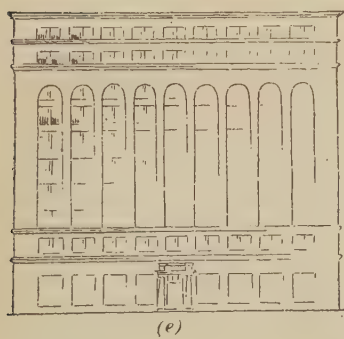
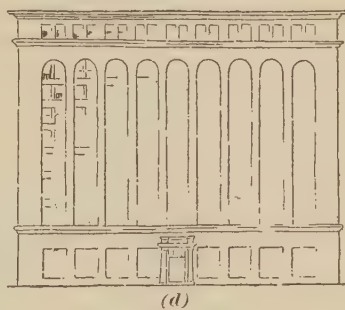
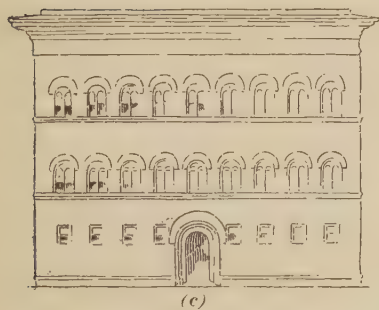
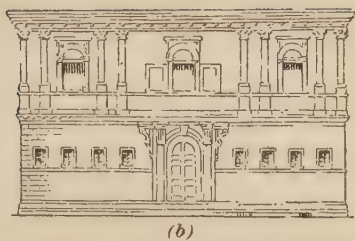
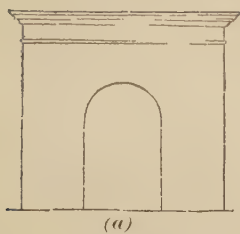


FIG. 13

side masses of the triple are unsymmetrical, or unequal, the auxiliaries should be unsymmetrical also. Generally speaking, the smaller or less pretentious auxiliary should be placed against the larger general mass, and the larger of the auxiliaries should be similarly placed with regard to the smallest of the triple masses, as in Fig. 12 (*d*).

In treating parts of a composition as auxiliary masses, it should be borne in mind that they must be smaller than the principal parts of the masses to which they are attached; also, they should be so different in treatment as to leave no room for doubt as to whether they are principal parts or auxiliary parts.

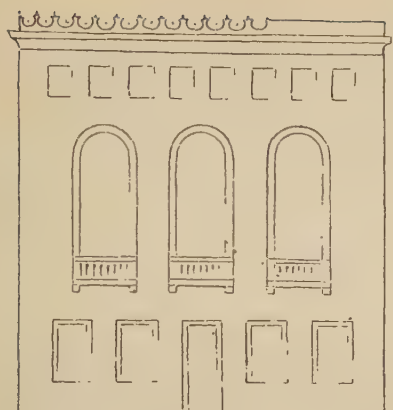
USE OF MOLDINGS

26. Moldings are used in architectural design to subdivide masses by means of horizontal bands. They are of varying forms, but their general purpose, namely, the production of horizontal lines of shadow, is the same in all cases. The essential difference in appearance between classic and Gothic buildings is due to the difference in the direction of their prevailing lines.

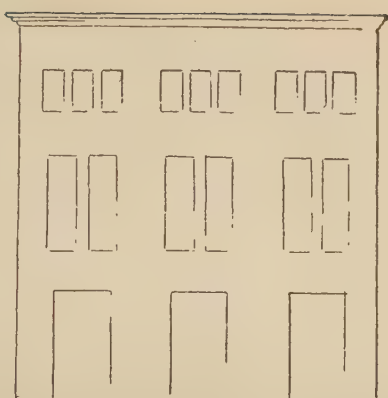
In the subdivision of buildings by moldings, the same rules apply as in the grouping of masses. One surface looks well alone. Two equal surfaces also look well, but they must be treated differently in order to secure variety of effect with equality of value in the two members. Three surfaces always look well together, but the middle one should as a rule be the largest.

27. When one surface is exposed by itself, a wide, strong cornice should surmount it, in order to emphasize its finish at the top, and one prominent detail should always relieve the face, as in the triumphal arch, Fig. 13 (*a*), and the Strozzi Palace, Fig. 13 (*c*). When two subdivisions are used, the lower one had better be treated with heavy constructions and small window openings, and the upper division with light pilasters and arched openings, as in (*b*).

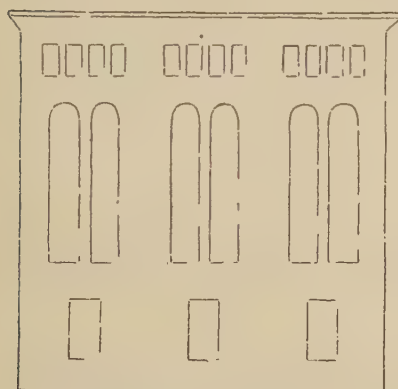
With a subdivision into three parts, the problem is a very simple one. Three *equal* parts require a simple treatment in



(a)



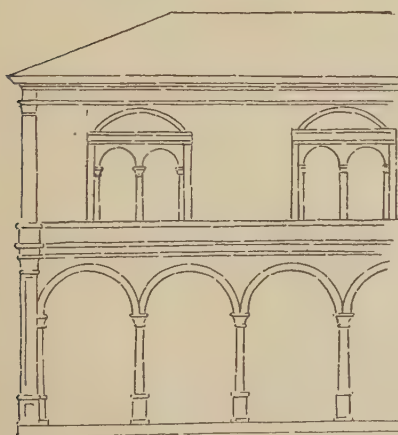
(b)



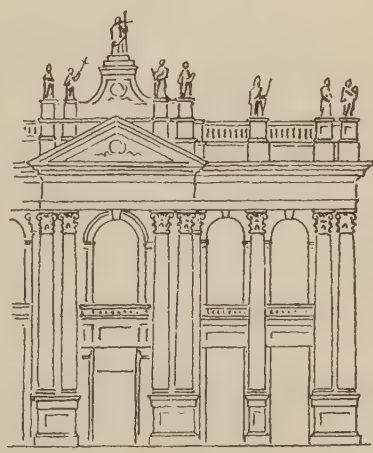
(c)



(d)



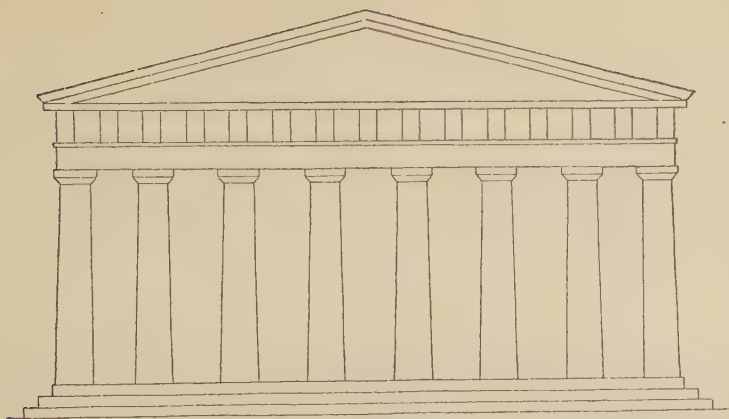
(e)



(f)

each part and a broad cornice over the whole, as this unites it into one composition, as in the Farnese Palace, Fig. 4, *History of Architecture and Ornament*, Part 4. Three *unequal* parts require that the largest part shall be in the middle and usually that the smallest part be at the top, as in (*d*), although the latter arrangement is not always necessary. Where the largest part is at either the top or the bottom, the two smaller parts fall together and are likely to look like a single subdivision in two parts. The subdivision with the largest part in the middle and smallest at the top comes very near the classic subdivision of the pedestal, column, and entablature, although in its present application, it may for convenience be called the basement, superstructure, and roof. With this idea in mind, it must be understood that this broad middle section must never be cut up into smaller subdivisions by moldings. It can and should as a rule be treated with vertical lines of piers or columns, as in Fig. 13 (*d*), but horizontal lines must be omitted entirely. However, satisfactory effects can be had by using horizontal moldings to subdivide the basement and roof divisions, as shown in (*e*). This was sometimes done in the classic temples, as shown in (*f*).

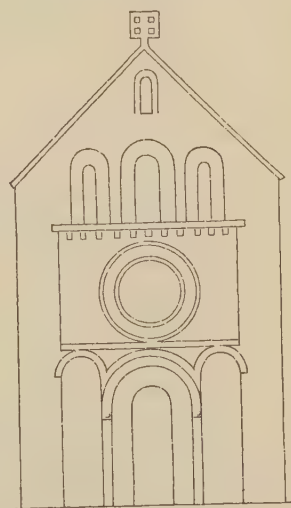
28. Horizontal subdivisions may be effected without moldings if the window treatment will permit. In Fig. 14 (*a*) it is evident that the wall is divided into three horizontal bands by three sets of windows so arranged as to avoid an appearance of vertical piers extending from the ground up. It is a maxim of good construction that openings shall come over openings, and piers over piers; but here there is a different condition of affairs owing to the desire to obviate vertical lines. However, this violation is compensated for somewhat by the fact that the openings in the upper story are greater and the superimposed weight of masonry therefore somewhat less.



(a)



(b)



(c)



(d)

FIG. 15

ARCHITECTURAL PROPORTION

METHODS OF PROPORTIONING MASSES

29. Architectural proportion is not a ratio between one dimension and another, as of length to breadth or of breadth to height, but is rather a ratio of mass to mass, either in surface or in solid. While it is a generally accepted theory that a tall, narrow building should possess tall, narrow windows, as is exemplified in Gothic architecture, it does not follow that a low, broad building should have wide, squatty windows. It is very important, therefore, to consider some rule that may be adopted to determine this relation of proportion between mass and detail.

That such a proportion existed in ancient architecture is evident, but there is nothing to prove that this proportion was a mathematical one. However, it is necessary to have a point at which to begin to study a complex subject; therefore a start will be made with architectural proportion from a mathematical basis, even if by so doing it will only be possible to learn what to avoid.

30. The Greek temples were broad, low buildings, with short columns, low pediments, and a stylobate of about three steps. The columns were from four to six times their diameter in height, and a feeling of horizontal lines predominated in the composition. This is clearly shown in the façade of the Parthenon, Fig. 15 (*a*).

The Roman columns, however, were designed to be from eight to ten diameters in height, and, consequently, not only a steeper pediment is found, but also an increased elevation of the building above the ground. The façade of the temple of Fortuna Virilis at Rome, Fig. 15 (*b*), shows the columns resting on a high podium, instead of on a low stylobate, and

the pediment inclined at an angle of about 27° instead of 11° , as in the Parthenon.

Later, when Romanesque architecture was fully developed from its classic ancestor, we find that the pediment has become a gable and all the other structural lines have assumed a perpendicular feeling, as in Fig. 15 (*c*), directly in contrast to the classic feeling that characterized Grecian architecture.

Finally, the perfected Gothic style succeeded the Romanesque and exceeded it in the perpendicular tendency of its detail, and at the same time the spire, Fig. 15 (*d*), is found superseding the pointed gable in the effort to emphasize the vertical feeling in design.

Why, then, are two structures so entirely unlike, so diametrically opposite, as the Grecian temples and the Gothic cathedral, equally admired? The only answer to this question is that the buildings of each particular period were carefully proportioned to suit the requirements of each system of design. It is not possible to lay down a set of rules that will determine the proper relation of surface to surface in every case of design, but an approximate rule can be given, and with this as a foundation and good taste as an alternative, satisfactory results can be approached in nearly every case.

31. In applying any rule of this character, it must be borne in mind that there are certain details of a building that cannot in themselves be compared, although their arrangement and emplacement may. For instance, a column, being a solid member of support, cannot be compared directly with a window, because the window is a void member over which something must be supported. A lintel cannot be compared with the mass of the entire structure, because it relates only in length and depth to the opening it spans. Chimneys, turrets, etc. are appendages that may or may not form a prominent detail of the building, and are therefore exempt from any rules governing proportion of fixed masses.

It must also be borne in mind that if it were possible to design all parts of all buildings according to a fixed mathe-

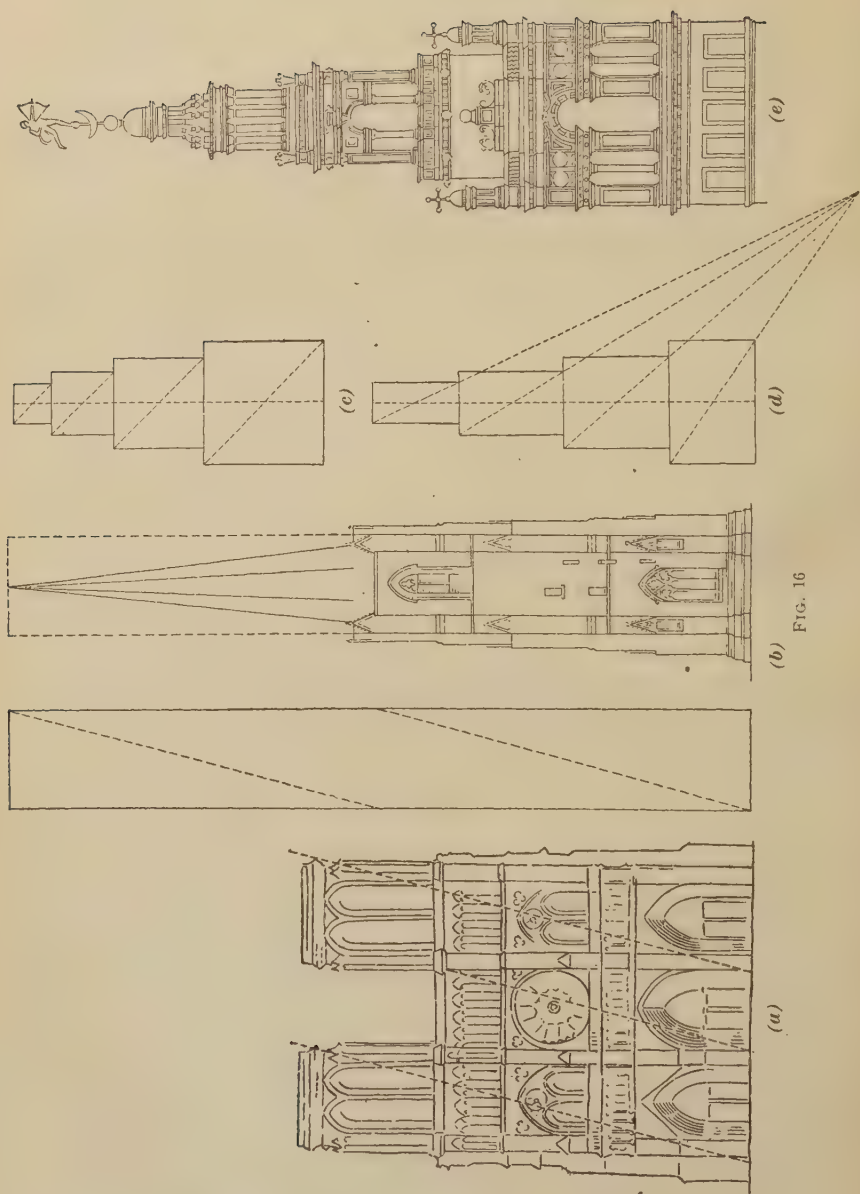


FIG. 16

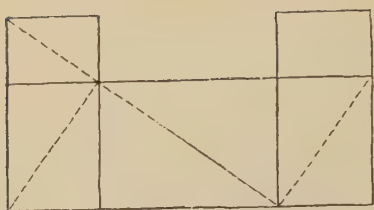
mathematical basis, there would be no variety or originality in design from one generation to another.

32. The drawing of diagonal lines parallel to each other will lead to a proportioning of some details that, when modified somewhat according to conditions and taste in each case, will produce admirable results. In Fig. 16 (*a*) is shown the front elevation of a Gothic church.

The towers constitute a group of two masses connected by a minor detail. The parallel diagonals determine the proportion of these masses to each other and at once give a general relation to start with, even if this relation cannot be strictly adhered to throughout. This proportion exists in the façade of the Cathedral of Notre Dame, Fig. 1, *History of Architecture and Ornament*, Part 3. The same principle can be applied to a low composition, as is shown in Fig. 11 (*e*), where a mass and two auxiliaries are so proportioned.

The proportions of a spire in a Gothic church can be determined by drawing a diagonal parallel to the diagonal of the construction, as in Fig. 16 (*b*). But here is where the treacherous side of the system begins to show itself, as parallel diagonals will not give such satisfactory vertical proportions of mass as they will of horizontal ones. However, this discrepancy is more a matter of perspective than of exception to the rule, although comparative contrasts have also something to do with it.

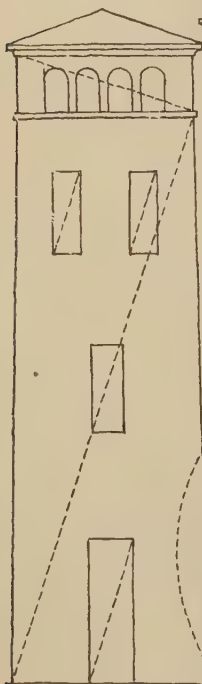
In (*c*) is shown a group of three details superimposed in a tower composition. Proportioned on the diagonal, these details have a low, flat appearance, thereby determining at once the inapplicability of this rule for this purpose. This flat appearance is exaggerated when the series is observed in perspective, as the projection of each detail below the other hides some of the one above. The members in a vertical composition should therefore be *stilted* and the diagonals drawn so as to radiate from a given point, as in (*d*). Even after deciding the general proportions in this manner, it is likely to be subsequently found that general appearances require some rearrangement in order to satisfy the



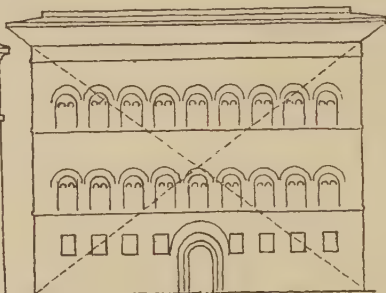
(a)



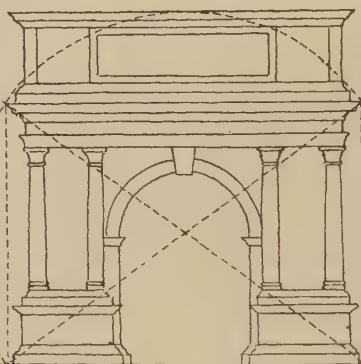
(b)



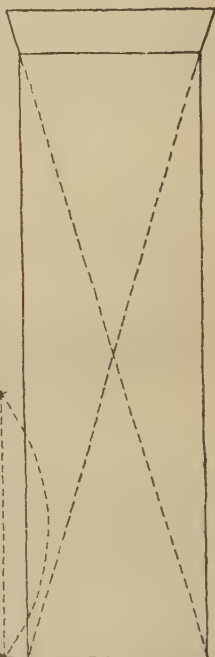
(c)



(d)



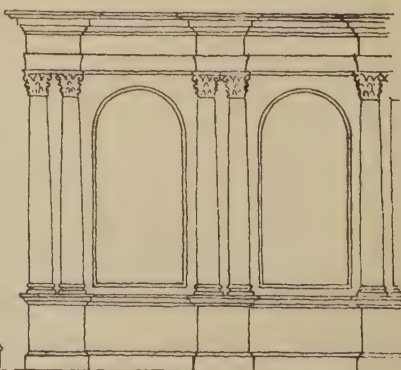
(f)



(e)



(g)



(h)

FIG. 17

demands of good taste. This construction closely approximates the tower of Madison Square Garden, as shown at (e).

33. Another application of the diagonal is found in its combination with its perpendicular. Where two vertical masses are united by a horizontal mass, as in Fig. 17 (a) and (b), the perpendicular to the diagonal of the vertical masses will serve as a diagonal of the horizontal mass, and the continuation of the diagonal of the horizontal mass will mark the height of the perpendicular mass above the horizontal one. This proportion exists in the propylæa at Munich, Fig. 82, *History of Architecture and Ornament*, Part 4.

For the proportioning of subordinate details, such as windows, etc., the diagonal serves directly in towers and similar structures, as shown in Fig. 17 (c), and the perpendicular to the diagonal in low and long buildings as in Fig. 13 (c). The diagonal of a façade will establish an appropriate rule for limiting the projection of the cornice, which in most instances will give approximately good results, as shown in Fig. 17 (d), which is an outline of the Strozzi Palace, Fig. 9, *History of Architecture and Ornament*, Part 4. The classic cornice was proportioned to the height of the structure or of each order introduced into it. But classic buildings were never built in a multitude of stories, and with the towering office buildings of modern times, a classic cornice proportioned to the height of the structure would be as impossible as on the tower shown in Fig. 17 (c). The diagonal of the façade, as in Fig. 17 (d) and (e), however, gives very satisfactory results for both high and low buildings. The intersection of the diagonals establishes a point from which an arc can be struck to establish the height of the parapet or attic story, as shown at (f). This method of proportioning should serve only as a suggestion of a standard near which the designer should work. The ratio of the details of the classic orders in terms of the diameter is subject to alteration under certain conditions and the use of the diagonal must be practiced with equal liberality.

In Fig. 14 (*b*), the grouping of the windows causes the composition to assume a series of both vertical and horizontal bands, the openings increasing in area from the lower story upwards, while the superimposed masonry is proportionately less. The same principle is carried out in (*c*), but with a greater variety of opening, so as to divide the façade into three equal bands. For a two-story structure, a symmetrical grouping such as shown in (*d*) gives satisfactory results, but should be varied if the building is a long

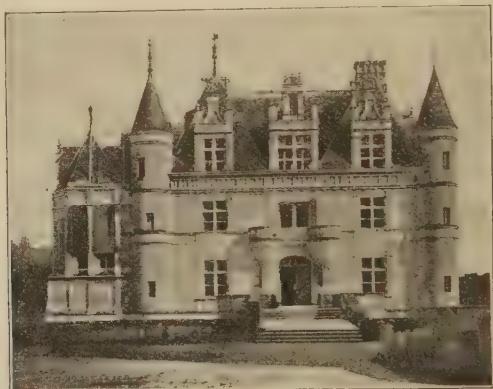


FIG. 18

one so as to prevent monotony. The grouping of the windows over a pair of openings in the lower story, as shown in (*e*), presents greater areas of wall in the second story, and while this makes a pleasing arrangement generally speaking, care must be exercised to avoid the appearance of a building set up on stilts or props. The union of two stories in a one-story composition, as in (*f*), is frequently resorted to, and here the structural conditions are deliberately misrepresented to produce effect.

GROUPING OF PRINCIPAL DETAILS

34. It is not always easy to distinguish whether a certain detail is a principal mass or a subordinate mass, and where any doubt is likely to exist as to this identity, the part



FIG. 19

in question should be emphasized or subdued in order to make it conform to the part assigned to it in the general composition. **Subordinate masses** are those masses which can be entirely removed from a composition without in any way destroying the completeness of the main composition.

The château of Chenonceau, Fig. 18, presents in composition a single mass with five principal details, or subordinate masses. These are the three dormer windows and the two corner turrets. Remove these, and the principal mass would remain the same. This is due to the fact that the principal details are so subordinate to the principal mass that their presence does not detract from its value in any way.

35. Grouping of a Simple Mass.—For general practice, take, to begin with, a simple mass that is rectangular and symmetrical, with a gable roof extending from end to end, as shown in Fig. 19 (*a*). The long side is to be relieved by a subordinate mass that will be introduced as a center gable, as in (*b*). This gable, however, is so long, and so similar to the main gable that it detracts from the importance of the principal mass and claims recognition as a principal part itself. Therefore, it must be subdued so as not to be so conspicuous. It may be compelled to show its subordination as a large dormer, as in (*c*), it being evident that a dormer must be subordinate to a projecting wing, or the gable can be lowered until it appears as in (*d*); or, the form of the roof can be changed to contrast it with the main gable, as in (*e*). The form of the body can also be altered as in (*f*), and thus, simply by the addition of an octagonal turret, a rectangular rustic cottage can be rescued from the ranks of the commonplace and classified in the lists with the picturesque and beautiful. As a matter of fact, this is exactly what was done, this illustration being taken from an original one of a little French cottage in Angers.

36. A single turret placed unsymmetrically is a very satisfactory treatment in some compositions, and has been used in many instances in both medieval and modern architecture. The entrance to the Hotel de Ville, Bourges, France, Fig. 20, presents a most satisfactory composition, and yet nearly every detail is unsymmetrically placed. The openings are not in the center of the pavilion, and the unsymmetrically placed turret was an absolute necessity in order to balance the composition.

37. Grouping of Two Details.—In the grouping of two principal details, the same rules apply as for the grouping of masses, except that there need be no connecting link between the details, as the mass itself on which they are placed unites them into one composition.

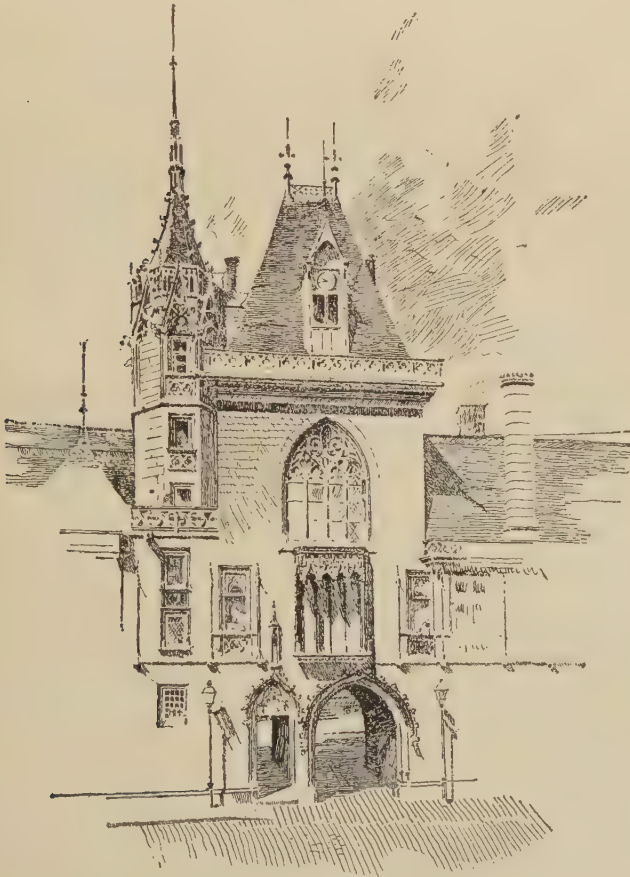


FIG. 20

The two gables shown in Fig. 21 are simple details in the composition and form an inferior group of two. They are unequal in size and different in detail, but they are near

enough alike to present the impression that one is a primary detail and the other a secondary detail.

38. Grouping of Three Details.—In grouping three principal details, great care must be exercised. Details that are exactly similar are likely to lead to unpleasant impressions. Three dormers, three bays, or three wings may be made to appear all right if they do not interfere with, or tend to detract from, the mass itself. It is always best, however, to have one of the three larger than the other two, as the monotony otherwise likely to exist can then be overcome. The three dormers on the château of Chenonceau, Fig. 18, are similar details, but the emphasis given



FIG. 21

the center one relieves the group from monotony. Three similar gables equal in effect must be entirely subordinate to the mass, as a uniform arrangement of this character is a difficult and risky one to undertake.

In a group of three principal details, the effect may be obtained not by adding anything to the mass, but by dividing the mass into subordinate parts, as shown in Fig. 17 (*g*). The central part can to advantage be made somewhat larger than the extremes, and thus relieve the composition of all feeling of monotony. This treatment is frequently found in church architecture, where the façade is divided into bays by means of buttresses, as in Fig. 17 (*g*).

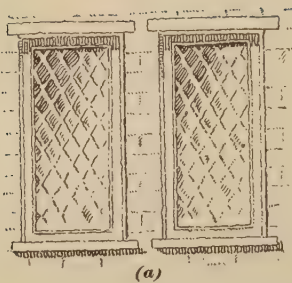
39. Grouping of More Than Three Details.—A group of more than three details can be arranged if they are alike and of one purpose, as, for example, the gable dormers in the Château de Blois, Fig. 6. Where the number of these details is uneven, it is better to emphasize the central one by making it somewhat larger than the others, or treating it in a different manner. With an even number of details no such emphasis is necessary, but effort should be made to avoid a feeling of continuity.

GROUPING OF MINOR DETAILS

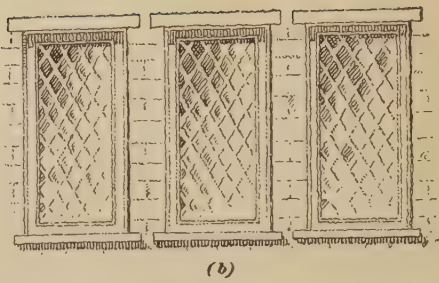
40. The grouping of such minor details as doors, windows, pinnacles, turrets, dormers, etc. is a matter of utmost importance in architectural composition, being second only to the masses themselves. An unavoidable objectionable arrangement of masses may often be compensated for by a skilful handling of the **minor details**. Minor details, while governed largely by the same rules as principal masses, can be handled more freely and altered to suit special conditions more readily than can the masses themselves.

Minor details may be divided into two classes: *voids* and *solids*, the former consisting of doors, windows, intercolumniation, etc., and the latter of piers, columns, and wall surfaces. It is essential that one should be fully cognizant of the effect produced by a detail, as a number of windows may be made to appear in them as a series of openings or to give the appearance of a series of piers, according to the method of treatment, as shown in Fig. 17 (*g*) and (*h*).

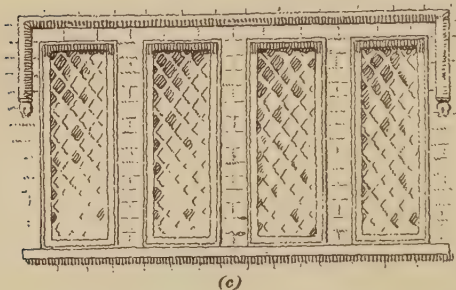
41. Windows may be grouped in pairs or in triplets, as shown in Fig. 22 (*a*) and (*b*); but where more than three are included in one group, they should be included under one dripstone, as in (*c*), or within one panel, in order to preserve the idea of unity. In triple windows, the middle one should always be slightly larger than the other two, as in (*e*); otherwise, it will look smaller. Three openings exactly alike and side by side will always produce an effect



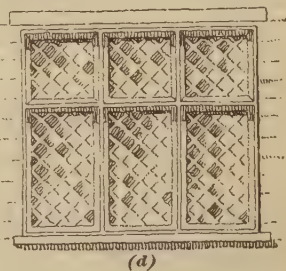
(a)



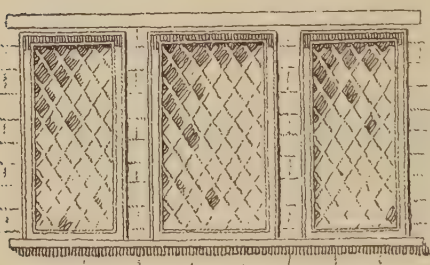
(b)



(c)



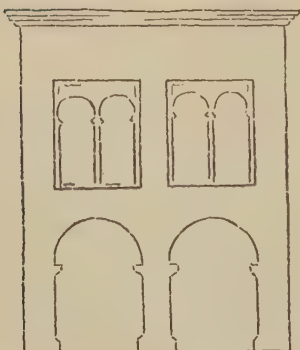
(d)



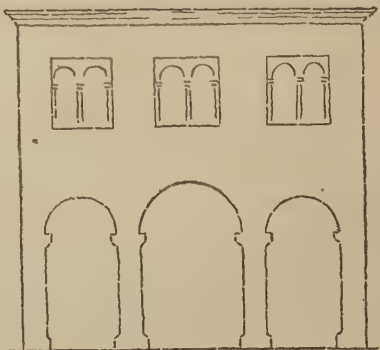
(e)



(f)



(g)



(h)

FIG. 22

of littleness in the middle opening, unless treated as one opening by means of mullions, as in (*d*).

Doors, as well as windows, may be grouped in pairs or in triplets; or, considered as openings, they may be grouped with windows, either symmetrically or unsymmetrically. The door and window arrangement shown in Fig. 5 (*b*) is quite common, both in the symmetrical and in the unsymmetrical arrangement.

42. A very pleasing arrangement of three symmetrical openings is shown in Fig. 22 (*f*). This arrangement is found in the entrance to the Villa Medici, Fig. 19, *History of Architecture and Ornament*, Part 4, and may be considered as analogous to a mass with two auxiliary masses. Almost identical with this in the character of its outline is the Tomb of Napoleon, Fig. 12, or St. Peter's at Rome, Fig. 44, *History of Architecture and Ornament*, Part 4.

The arrangement of the openings in the general mass is a matter of great importance, as on it all designs depend largely for effect. A combination of three openings in the second story over three openings in the first story gives a pleasing effect, and so does a similar arrangement of either two or four, although in the latter case there is a danger of a dual effect unless some special details are introduced to insure that the whole composition will be considered as a single mass. In repeating these arrangements, they should not be used in pairs, as in Fig. 22 (*g*), nor in triplets, unless the center is emphasized as in Fig. 22 (*h*).

In a group of two masses, the windows in the connecting mass should be uneven in number, so that the central opening may suggest an axial line on which the composition may be divided. The purpose of the connecting link is self-evident, and it is undesirable to have it identified entirely with the two masses at the ends. When a single mass is central and two auxiliary masses extend on each side, the openings should be even, so as to prevent any possibility of an imaginary axis through the auxiliaries, causing them to be considered as separate masses.

CLASSIC PROPORTIONS

43. As has already been stated in *History of Architecture and Ornament*, Part 1, Arts. 129 to 132, the details of classic design were based on a system of proportion established in the architectural orders. These classic proportions were made public during the Renaissance period by means of a series of papers written by different authors, the best known of these series being that of Vignola, published in 1563. The proportions of these classic orders must be known by the modern designer, as they are used in all constructions in which classic details are adopted. The system herein set forth varies somewhat from that of Vignola, but it is much simpler and therefore far better suited to modern practice, where the standard of measurement is based on the English foot or the French meter and their subdivisions into inches and centimeters.

THE ORDERS

44. In classic architecture, the several varieties of column and entablature were called **orders**. Each order, Fig. 23 (a), comprises a *column* with base, shaft, and capital, (with or without a *pedestal*, with its base, die, and cap), which is crowned by an *entablature*, consisting of an architrave, frieze, and cornice. The entablature is generally about one-fourth as high as the column, and the pedestal about one-third.

45. The principal member of the cornice is the *corona*, which is shown in Fig. 23 (h). Above the corona, the cornice is regularly terminated by a member originally designed to serve as a gutter to receive the water running down the roof. It generally consists of a large cyma recta, though the ovolo and the cavetto are often used. It is

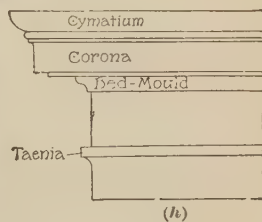
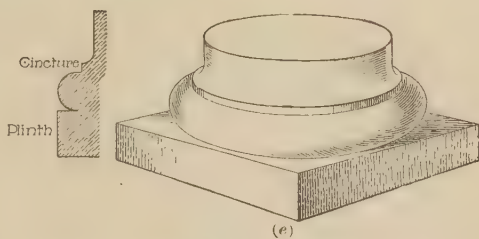
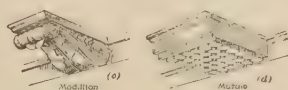
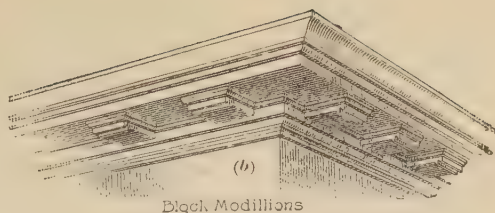
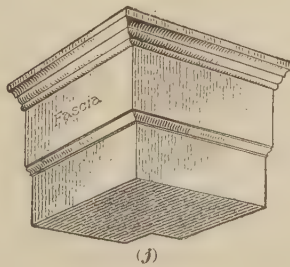
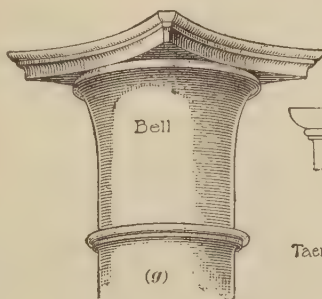
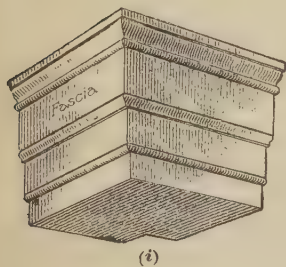
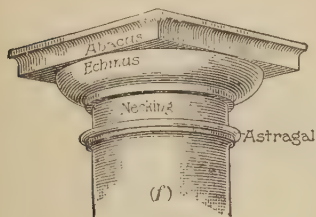
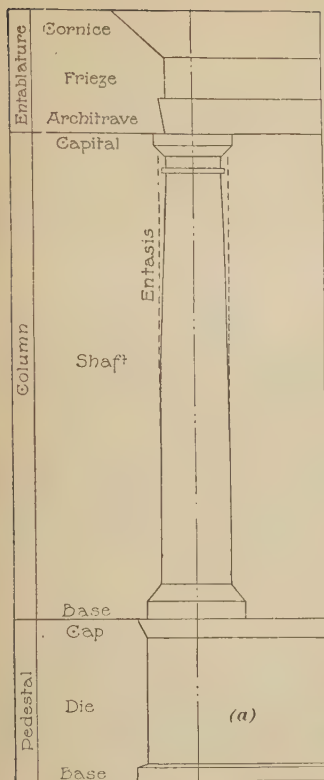


FIG. 23

sometimes called the *cymatium*, no matter what its shape may be.

The corona is supported by a molding or a group of moldings, called the *bed mold*. A row of brackets, termed *blocks*, Fig. 23 (*b*), *modillions* (*c*), or *mutules* (*d*), according to their shape, resting on the bed mold and supporting the soffit of the corona, is often added. At the top of the architrave is a projecting molding that, when square, is called a *tænia*, Fig. 23 (*h*), and the face of the architrave is often broken up into two or three bands, or fasciæ, as shown in (*i*) and (*j*).

46. The abacus of the capital also has a sort of bed mold beneath it. This mold, when convex, is called an *echinus*, Fig. 23 (*f*), from the sea shell, which it resembles in shape. The little frieze below it is called the *necking*. But if the bed mold under the abacus is concave, it dies into the necking like a large congé, and the two together constitute the *bell* of the capital, as in (*g*). The abacus is square in plan, but the echinus, or the bell below it, is round, like the column.

At the top of the shaft is a member called the *astragal* (*f*), consisting of a bead, fillet, and congé. It has a flat surface on top, as wide as the projection of the congé, as in (*k*). At the bottom of the shaft is another congé, and below this is a broad fillet called the *cincture*, as in (*e*). The base generally has, below the base moldings, a plain member called the *plinth*, which is square in plan like the abacus.

47. The shaft diminishes as it rises, as shown in Fig. 23 (*a*), the upper diameter being only five-sixths of the lower, and the outline is not straight, but curved. This curve, which is called the *entasis*, or bending, as of a bow, generally begins one-third of the way up, the lower third being cylindrical. The entasis is not to be confounded with the *diminution*, which is generally one-sixth, the upper diameter being five-sixths of the lower.

Generally, the pedestal also has a corona or cap and bed mold, but no gutter, above the die, and a base molding and plinth below it, as shown in (*a*).

48. In the choice and use of moldings, the tastes and fashions of the Greeks and Romans were quite contrary to those of their successors in the middle ages. The ancients preferred to use vertical and horizontal surfaces at right angles to each other, and seldom used an oblique line, or an acute or obtuse angle, as the Gothic architects did. They also preferred the cyma reversa, seldom employing the cyma recta, which in the middle ages was rather the favorite. Moreover, as has been said, the Gothic architects, in decorating a corner or edge, often cut it away to get a molding, but the ancients raised the molding above the plane of the surface to which it was applied. In the composition and sequence of moldings also, the classical architects generally avoided repetition, alternating large and small, plain and curved, convex and concave. The convex and concave profiles seldom describe an arc of more than 180° , and except in the case of the beak molding and of the bead, moldings are always separated by fillets. When a molding is enriched, it is generally by carving ornamental forms upon it that resemble its own profile, as in Fig. 57, *History of Architecture and Ornament*, Part 1. The Greeks frequently employed elliptical and hyperbolic profiles, while the Romans generally used arcs of circles.

49. Among the Greeks, the form shown in Fig. 41 (*a*), *History of Architecture and Ornament*, Part 1, was used by the Doric race, which inhabited Greece itself and had colonies in Sicily and Italy. This form was much unlike that used by the Ionic race, which inhabited the western coast of Asia Minor, and whose art was greatly influenced by that of Assyria and Persia. The Romans modified the *Ionic* and *Doric* styles, and elaborated the Corinthian order by the introduction of modillions in the cornice, as shown at *B*, *C*, and *D*, Fig. 88, *History of Architecture and Ornament*, Part 1. They also used a simpler Doric, called the *Tuscan A*, and a cross between the Corinthian and the Ionic, called the *Composite E*. These are the **five orders**. The ancient examples vary much among themselves and differ in different places.

VIGNOLA'S ORDERS—PLATE I

50. Plate I shows the proportions of the orders according to Vignola, in terms of the lower diameter of the columns. These vary in height from seven diameters to ten.

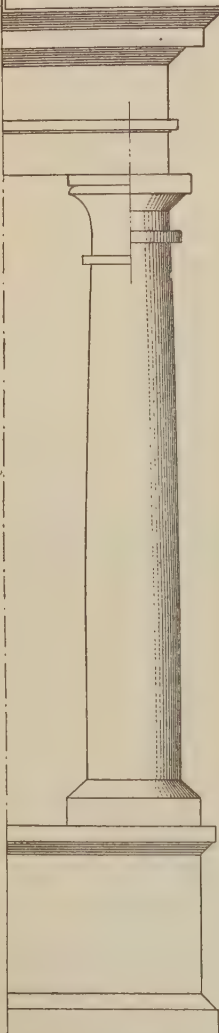
The entablature in all of them is ordinarily one-fourth the height of the column, but it is sometimes made as small as one-fifth. The projection of the cornice is the same as its height, except in the Doric order, where it is greater. The lower band of the architrave is made to come in line with the upper face of the shaft.

But it is only when seen in elevation that these relations obtain. When seen in perspective, as is generally the case, the cornice appears much larger, in proportion, and the frieze and architrave, being foreshortened, much smaller, and the architrave appears to overhang the shaft [see Fig. 25 (a)].

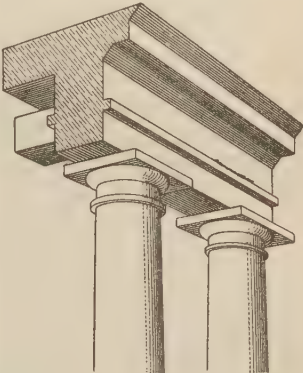
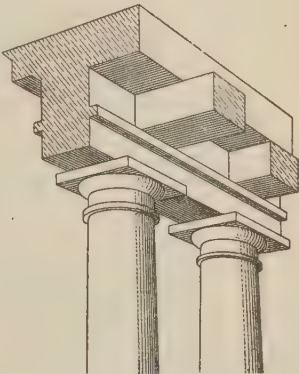
In the Greek orders, the column is from five to ten diameters in height and the entablature always about two diameters. In the Greek orders, accordingly, the taller the column, the lighter the entablature, relatively; but in the Roman orders, the taller the column, the heavier the entablature, actually. It follows that the weight of the Greek entablature is proportioned to the diameter of the column, irrespective of its height; of the Roman to the height of the column, regardless of its diameter. The Romans put the least weight on the shortest and strongest supports. The Greek system shows more regard for principles of construction; the Roman for principles of decorative composition.

Vignola used *half* of the lower diameter of the column as his unit of measure, or **module**. This he divided into twelve **parts** for the Tuscan and Doric orders, and into eighteen parts, called **minutes**, for the others, and he gives all the dimensions, both of the larger members and of the moldings, in terms of *modules*, and *parts*, or *minutes*, sometimes using even the quarter minute, or one one-hundred-and-forty-fourth of a diameter. But it is equally practicable

COMPARISON C

TYPE OF ORDER	NAMES OF FEATURES			GREEK DORIC		TUSC
	ENTABLATURE	1/4 to 1/5	CORNICE	CYMATIUM CORONA BED MOULD	1/2	1 3/4
			FRIEZE		3/4	
			ARCHITRAVE	TÆNIA	3/4	
	COLUMN	1	CAPITAL	ABACUS ECHINUS NECKING ASTRAGAL	1/2	7
			SHAFT			
			BASE	CINCTURE BASE MOULD PLINTH	NONE	
	PEDESTAL	1/3 ±	CAP	CORONA BED MOULDING	NO PEDESTAL BUT THREE STEPS THE STYLOBATE	TH
			DIE			
			BASE	BASE MOULD PLINTH		

THE ORDERS

DORIC		IONIC		CORINTHIAN COMPOSITE		PERSPECTIVE VIEW
2	3/4	2 1/4	7/8	2 1/2	1	
	3/4		6/8		3/4	
	1/2		5/8		3/4	
8	1/2	9	1/3 [1/2]	10	7/6	
	1/2		1/2		1/2	FROM WITHIN
IS ONE NINTH THE HEIGHT OF THE PEDESTAL						
PEDESTAL 1/3 [VIGNOLA]						
IS TWO NINTHS THE HEIGHT OF THE PEDESTAL						

and more convenient to use the whole diameter as a unit of measure, dividing it only into fourths and sixths, and occasionally using an eighth or a twelfth.

51. In Plates III, V, VI, VIII, X, and XII the first column on the left shows the vertical dimensions as given in Plate I. In the second column, these divisions are subdivided into equal parts, the third column giving a further division of the dimensions thus obtained. Most of these dimensions can be stated in terms of sixths or fourths of the diameter, as appears in the tables.

This analysis does not reach the smaller details, the shape and size of which must be learned by observation. Indeed, all these forms should be made so familiar that they can be drawn accurately from memory, these arithmetical relations being used only to test the accuracy of the result, or to discover how much the proportions adopted in any

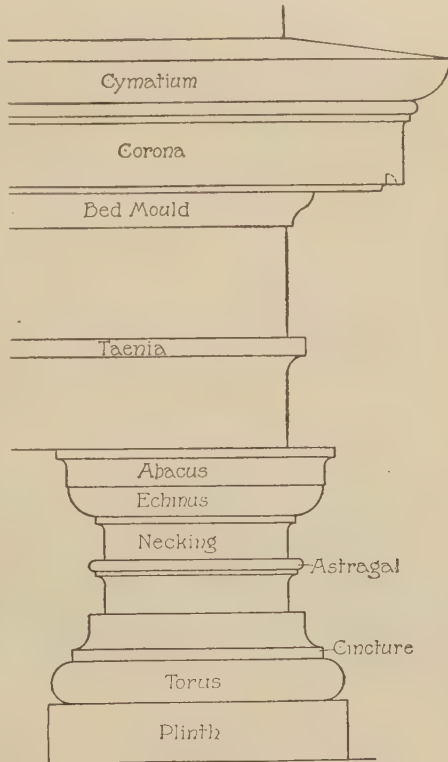


FIG. 24

given case differ from the regular type. *Vignola's orders are to be regarded only as an admirable standard that may be safely adopted when there is no occasion to do anything else, and may be departed from and varied whenever there is any reason for doing so. Vignola himself so regarded*

them. He did not adhere closely to his own rules, or generally adopt his orders in his own work. His Doric and Ionic are to be found, however, in the Villa Caprarola.

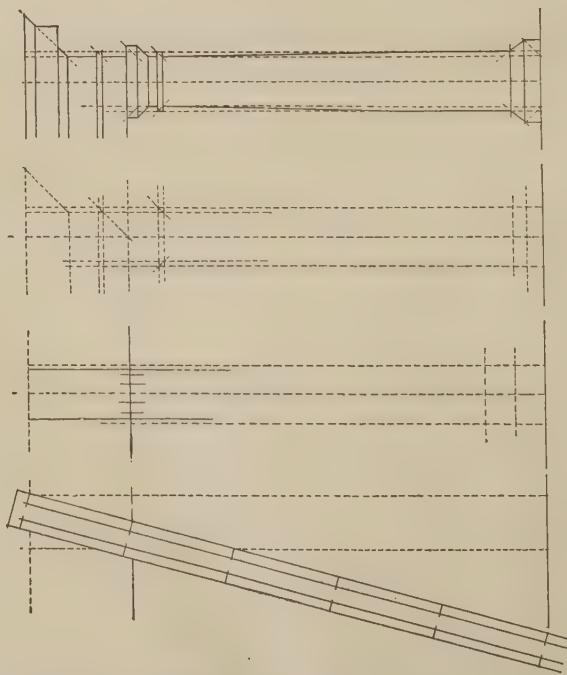
TUSCAN ORDER—PLATES II AND III

52. The distinguishing characteristic of the **Tuscan order** is simplicity. Any forms of pedestal, column, and entablature that show only few moldings, and those plain, are considered to be Tuscan. Vignola's Tuscan order, Fig. 24, is marked by the use of the ovolo in the cymatium, and by the frequent employment of the congé. The height of the column is seven diameters and that of the entablature, accordingly, seven-quarters, or a diameter and three-quarters. The base, capital, architrave, and frieze are each half a diameter high, and the cornice three-quarters. But this measurement includes not only the base itself, but the cincture at the foot of the shaft. Dividing the cornice into four parts, the capital into three, and the base into two, gives the principal horizontal divisions. The bed mold is a large cyma reversa. The abacus is seven-sixths of a diameter across, not including the fillet at the top, and it projects its own height from the face of the architrave above, which is in line with the necking below.

All the principal dimensions can be expressed in terms of fourths and sixths of the lower diameter of the shaft.

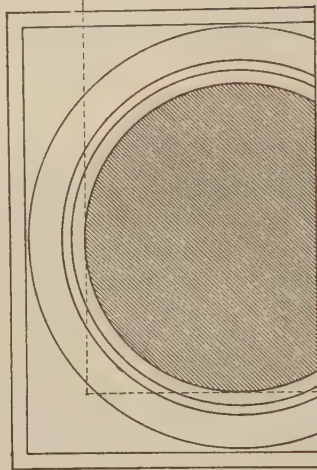
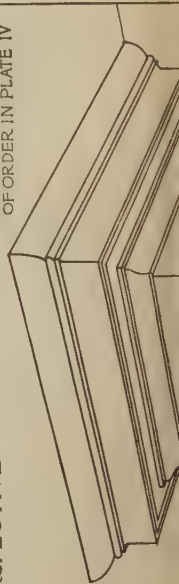
Vignola makes the width of the plinth a little greater than this, and sets the bed mold up one-twelfth, making the frieze wider and the corona narrower.

TUSCAN ORDER

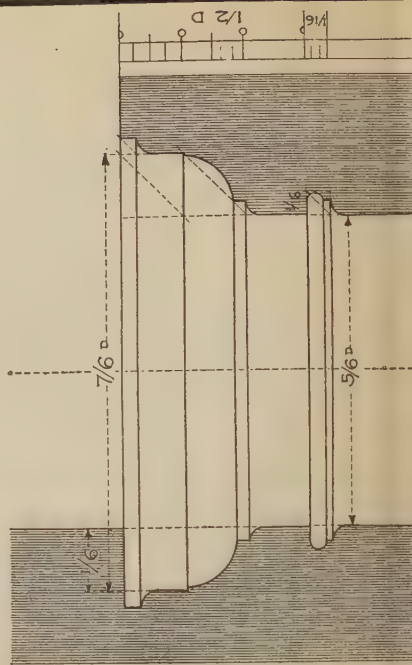


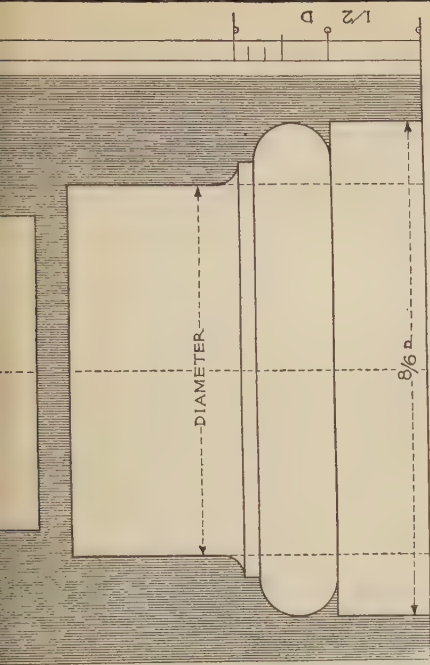
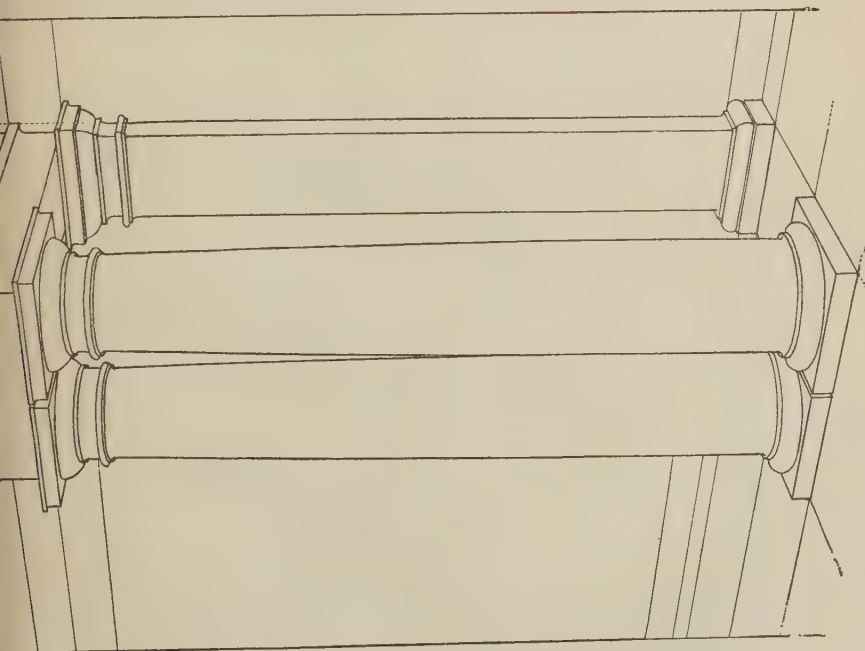
PERSPECTIVE VIEW

DRAWN TO THE SCALE
OF ORDER IN PLATE IV

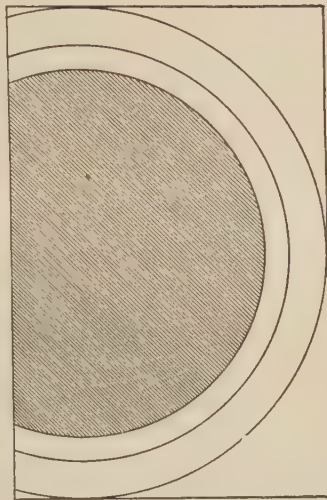


PLAN OF CAPITAL LOOKING UP



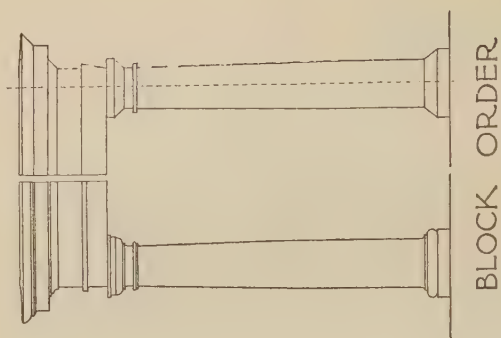
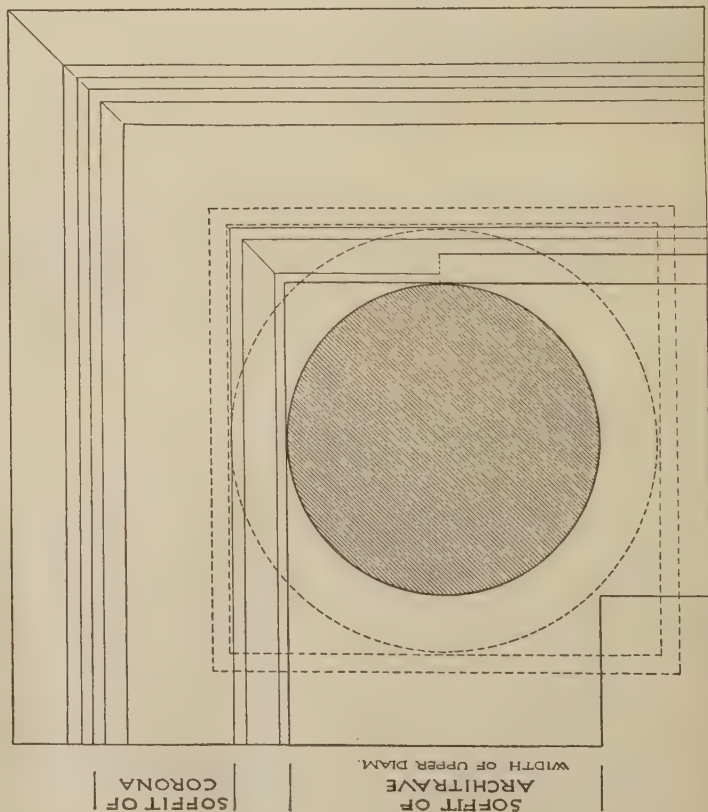


ELEVATION OF CAPITAL AND BASE



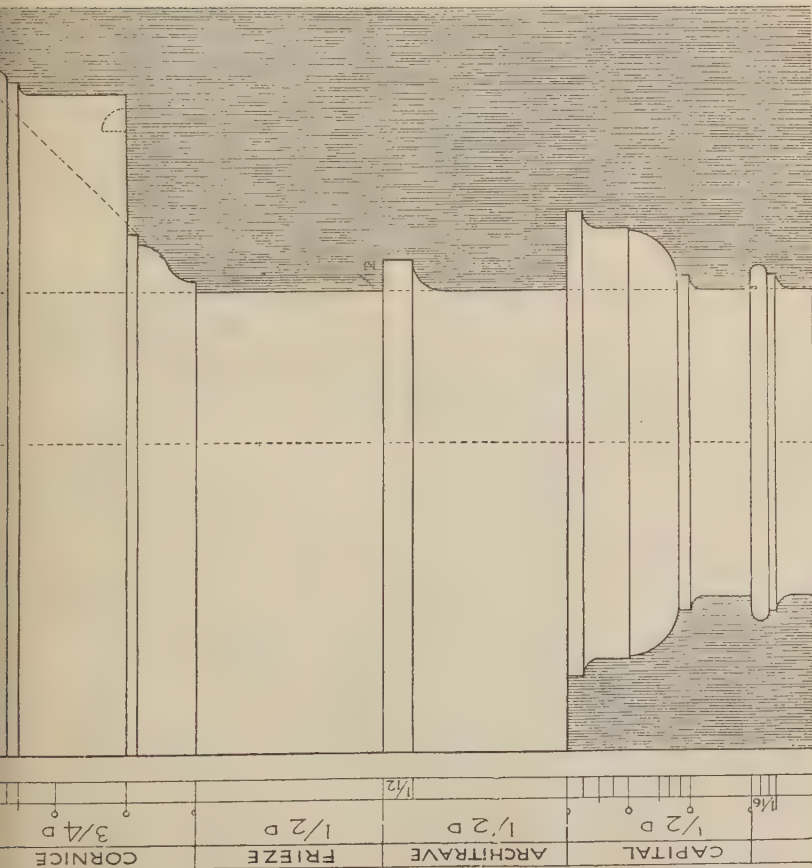
PLAN OF BASE

TUSCAN ORDER

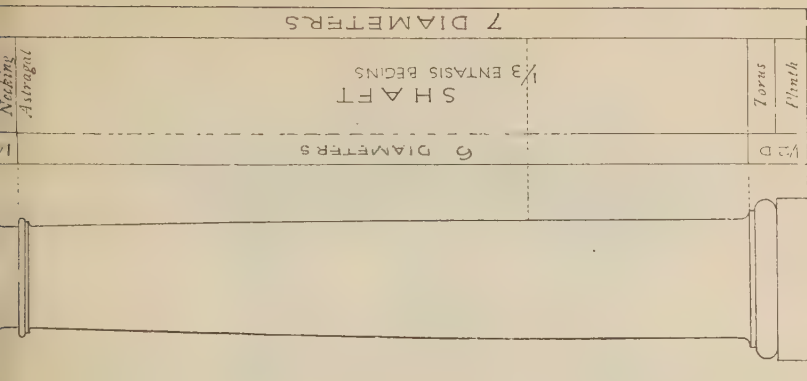


COMPLETE ORDER

Cymatium	$\frac{1}{4}$ D
Corona	
Architrave	
Taenia	

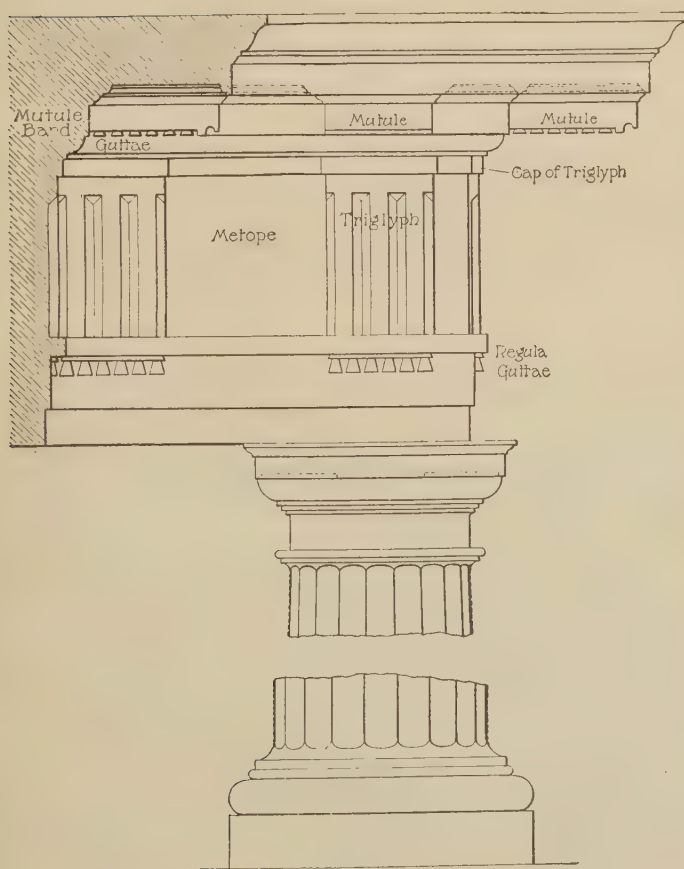


ELEVATION OF ENTABLATURE





(a)



(b)

TABLE OF THE TUSCAN ORDER

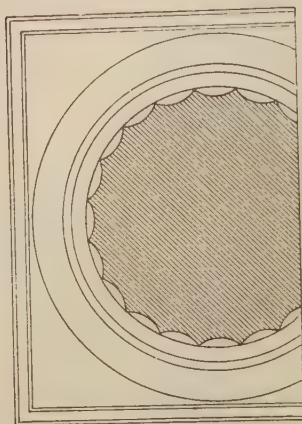
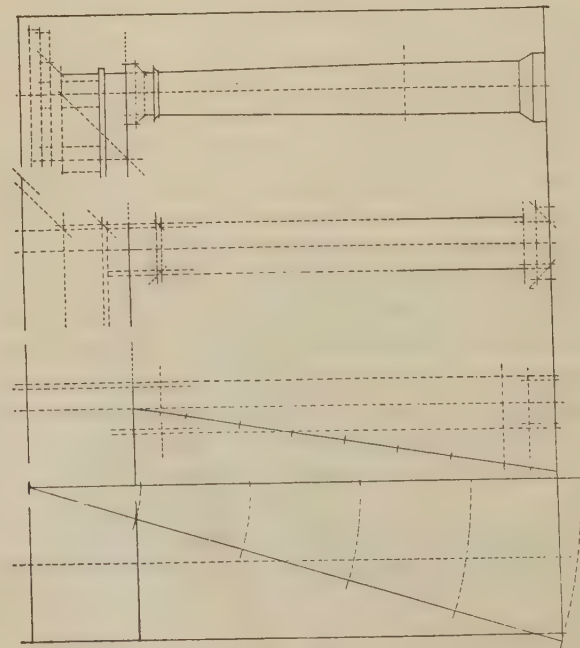
$\frac{1}{4} D$	equals	height of plinth.
$\frac{3}{4} D$	equals	{ height of cornice. projection of cornice.
$\frac{1}{6} D$	equals	{ height of necking. height of echinus. height of abacus.
$\frac{1}{2} D = \frac{3}{8} D$	equals	{ height of base, including cincture. height of capital. height of architrave. height of frieze.
$\frac{5}{6} D$	equals	upper diameter of shaft.
$\frac{6}{6} D$	equals	lower diameter of shaft.
$\frac{7}{6} D$	equals	width of abacus.
$\frac{8}{6} D$	equals	width of plinth.
$\frac{1}{12} D$	equals	width of tænia.
$\frac{1}{16} D$	equals	{ height of astragal. projection of astragal.

DORIC ORDER—PLATES IV, V, AND VI

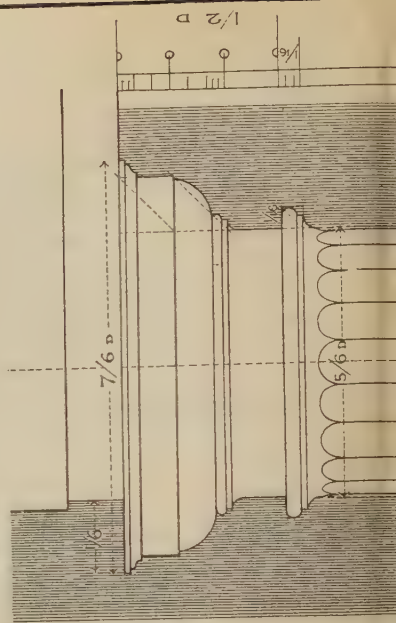
53. The distinguishing characteristics of the **Doric order**, Fig. 25, are features in the frieze and in the bed mold above it, called *triglyphs* and *mutules*, which are supposed to be derived from the ends of beams and rafters in a primitive wooden construction with large beams. Under each triglyph, and beneath the tænia that crowns the architrave, is a little fillet called the *regula*. Under the regula are six long drops, called *guttæ*, which are sometimes conical and sometimes pyramidal. There are also either eighteen or thirty-six short cylindrical guttæ under the soffit of each mutule. The guttæ are supposed to represent the heads of wooden pins, or treenails.

Two styles of the Doric orders are found in the classic monuments, the *mutular*. Fig. 25 and Plate V, and the *den-*

DORIC ORDER

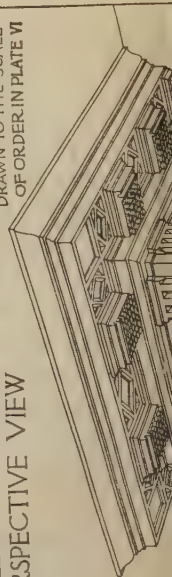


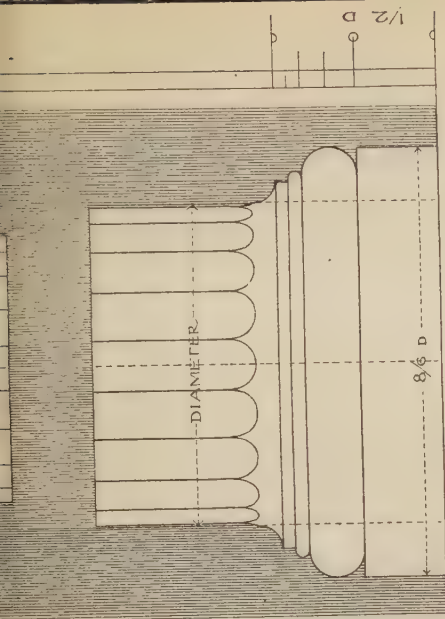
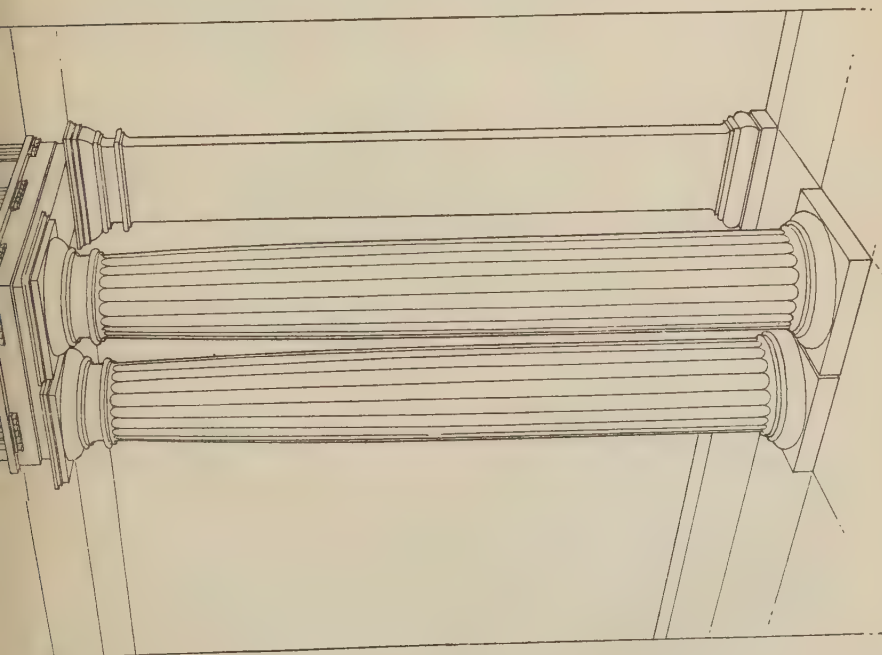
PLAN OF CAPITAL



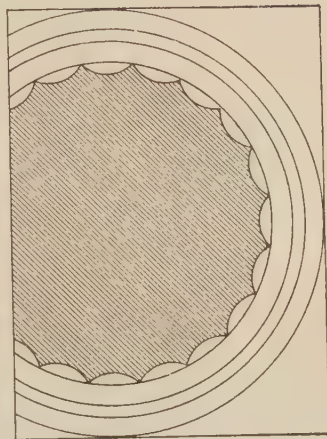
DRAWN TO THE SCALE
OF ORDER IN PLATE VI

PERSPECTIVE VIEW



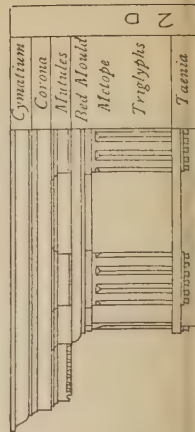
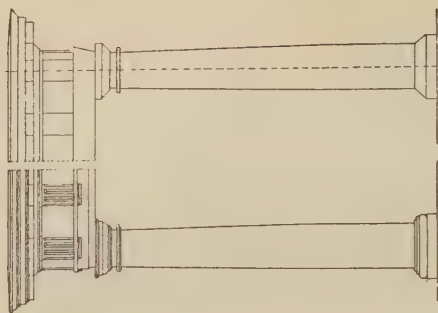
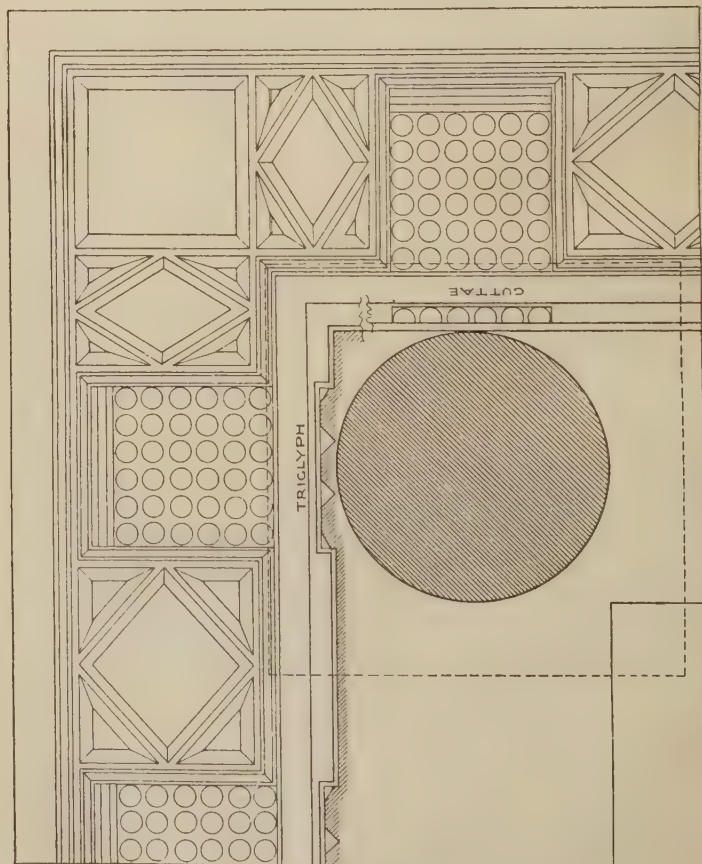


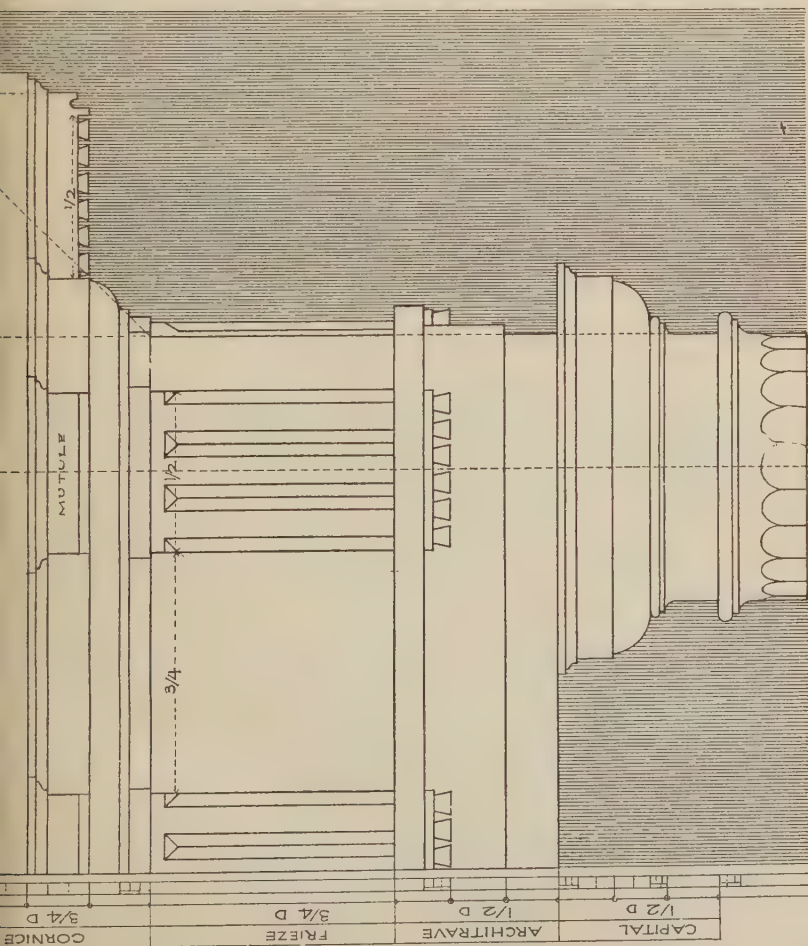
ELEVATION OF CAPITAL AND BASE



PLAN OF BASE

DORIC ORDER



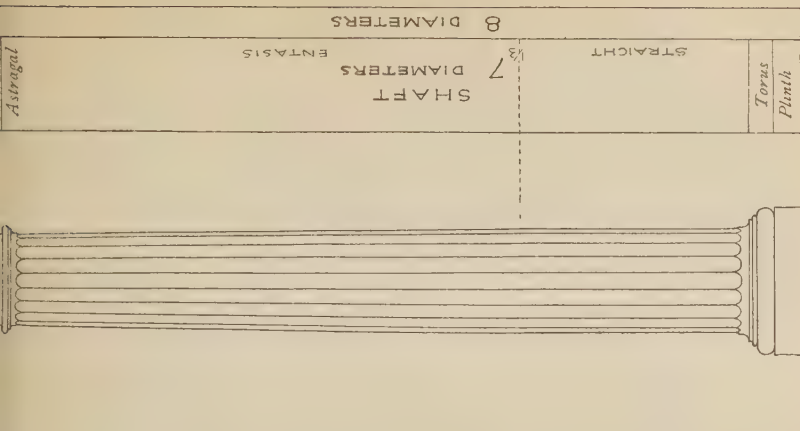


ELEVATION OF ENTABLATURE

COPYRIGHT, 1902, BY WILLIAM R. WARE
 COPYRIGHT, 1904, BY INTERNATIONAL TEXTBOOK COMPANY
 159-I L T 31C § 52

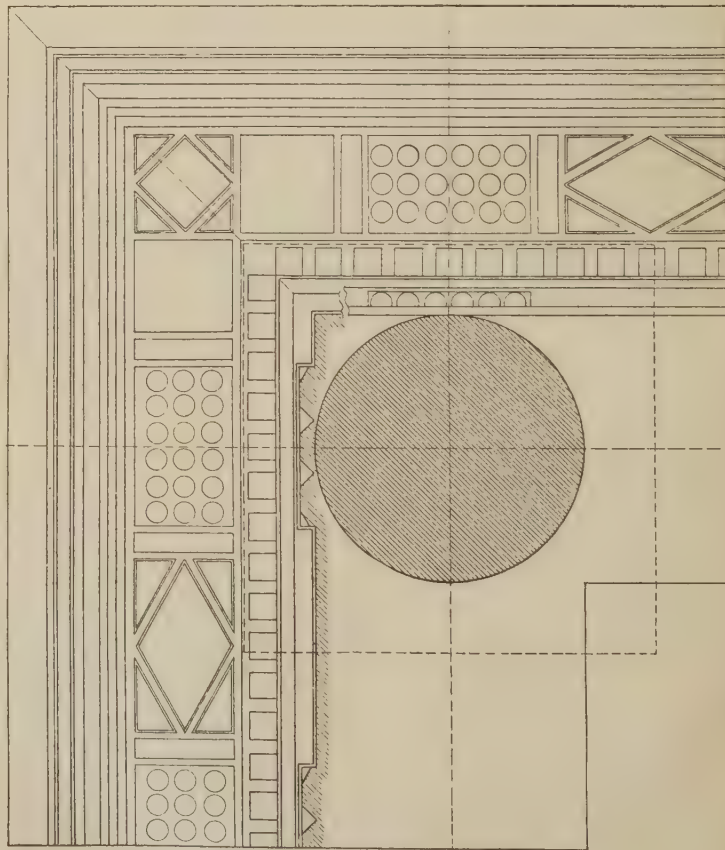
PLATE V

INTERNATIONAL TEXTBOOK COMPANY
 SCRANTON, PA.



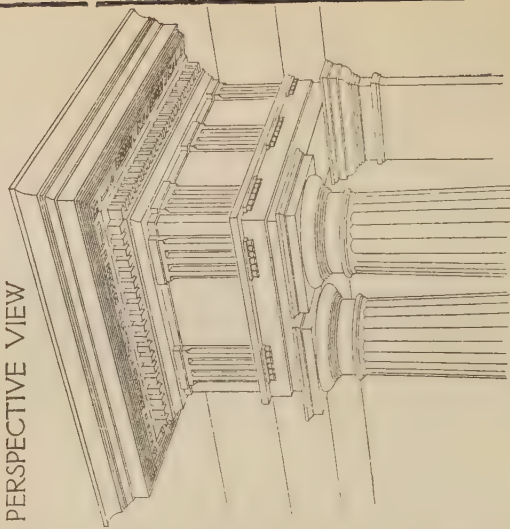
DORIC ORDER

[DENTICULATED]

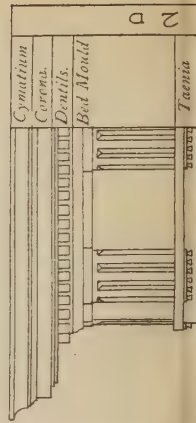


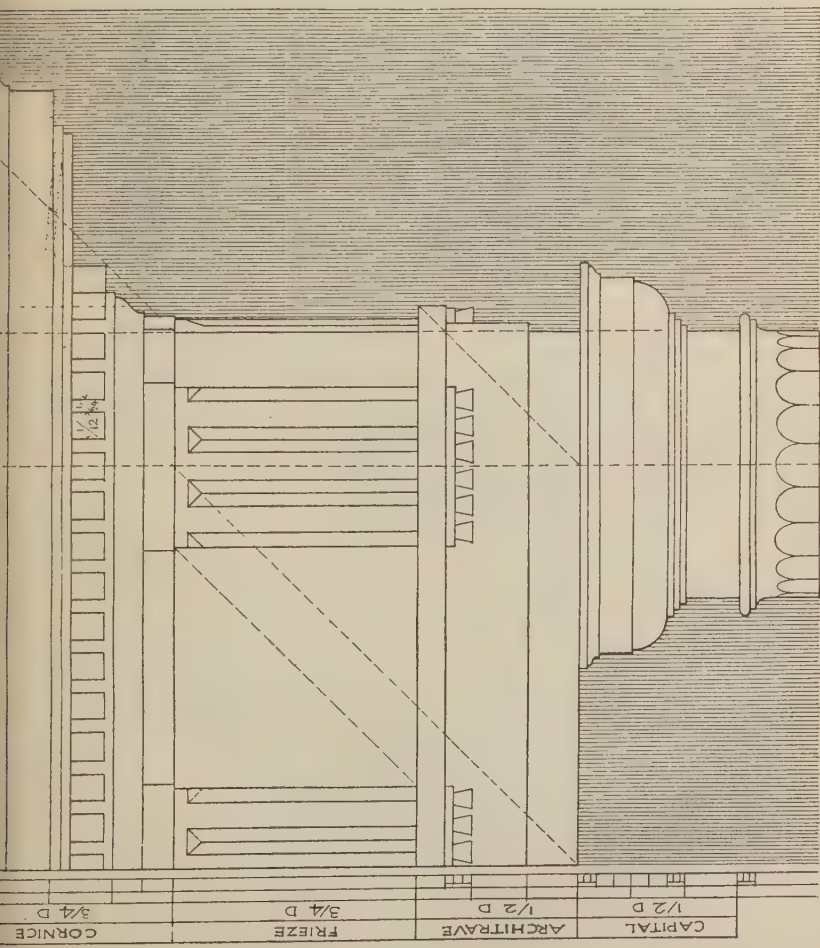
PLAN OF ENTABLATURE LOOKING UP

PERSPECTIVE VIEW

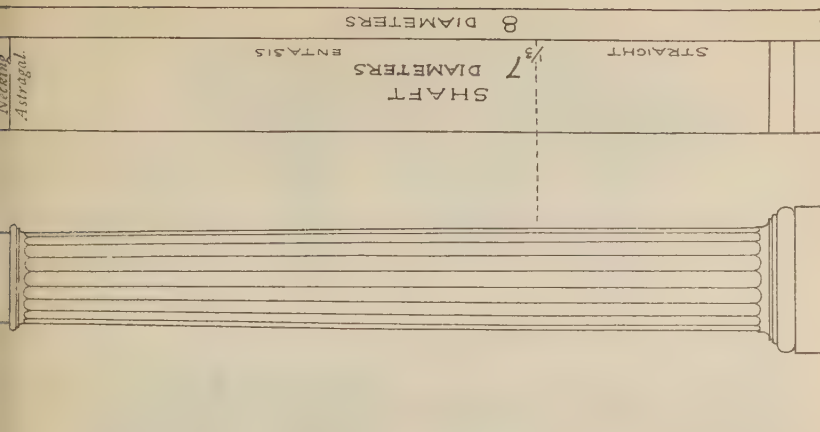


COMPLETE ORDER





ELEVATION OF ENTABLATURE



*Necking
Astragal*

COPYRIGHT, 1902, BY WILLIAM R. WARE.

COPYRIGHT, 1904, BY INTERNATIONAL TEXTBOOK COMPANY

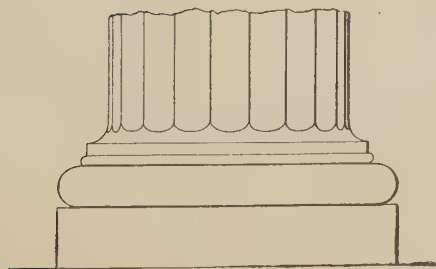
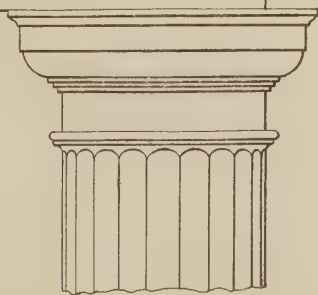
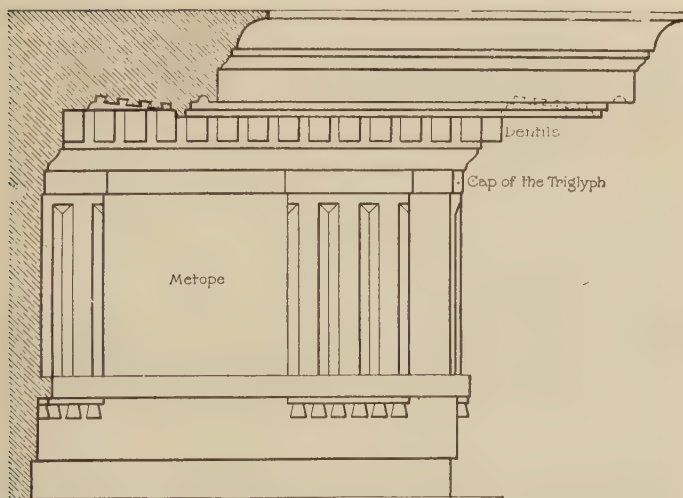
159-ILT 31C \$ 52

INTERNATIONAL TEXTBOOK COMPANY

SCRANTON, PA.



(a)



(b)

FIG. 20

ticated, Fig. 26 and Plate VI. They differ chiefly in the cornices. In both of them the height—three-quarters of a diameter—is divided into four equal parts, the upper one embracing the gutter, or cymatium, and the fillet below, the next the corona and the small cyma reversa, or cymatium, above it. But the bed molds are unlike. In both of them, the lower member of the bed mold is a broad fillet, a sort of upper *tænia*, called the *cap of the triglyph*. This, unlike the *tænia* below, breaks around the angles of the triglyph, serving as a sort of crowning member, or cymatium, to both the triglyph and the metope.

54. Mutular Doric.—In the mutular Doric, Fig. 25, above the cap of the triglyph, is a narrow fillet that does not break around the angles and accordingly shows a broad soffit over the metopes and at the corner of the building. These two fillets occupy the lower half of the lower quarter of the cornice. The upper half of the lower quarter, above this little fillet, is an ovolo, and above this, the second quarter of the cornice is occupied by a broad fascia, called the *mutule band*, on which are planted the mutules, one over each triglyph, which are half a diameter wide, like the triglyphs below them. They are broad, low, oblong brackets, crowned with a fillet and cyma reversa, which also crown the mutule band between the brackets. On the soffit of each mutule are thirty-six guttæ and a drip molding.

55. Denticulated Doric.—In the denticulated Doric, Fig. 26, the place of the fillet and ovolo above the cap of the triglyph is taken by a large cyma reversa, the soffit of which is wider over the metopes than over the triglyphs, as is that of the small fillet in the mutulary. Above this molding is a band like the mutule band, but instead of brackets, extending out under the corona, it bears a row of small blocks, like teeth, called *dentils*. These are one-eighth of a diameter high, and are set one-eighth of a diameter from center to center, or edge to edge. If this last dimension is divided into thirds, two of these go to the

dentil, and one to the space between it and the next one. This space is called an *interdentil*, which is accordingly one twenty-fourth of a diameter wide. The dentil is thus one-eighth of a diameter long and one-twelfth wide, or half a sixth, or of the proportions of two to three, like the triglyph. The face of the last dentil on the corner and the side of the first one around the corner come together in elevation without any interdentil, giving the appearance of a *double dentil*, for the dentils are square in plan and the side is just as wide as the face.

As the triglyphs are a diameter and a quarter on centers, or ten-eighths, there are ten dentils to each triglyph and metope.

A dentil comes just over the axis of each column and there are three dentils between the one over the corner column and the double dentil on the corner, the farther edge of the third one being just over the face of the frieze, or five-twelfths of a diameter from the axis of the column.

The last dentil, or first half of the double dentil, is centered over the outer face of the bottom of the shaft (see Fig. 42).

The dentils constitute the upper member of the bed mold. They leave the chief part of the corona unsupported, but the soffit of the corona, which is slightly inclined, recalling the slope of the rafters, is not so wide as the soffit of the mutulary Doric, owing to this encroachment of the dentils. The mutules, which are very shallow, have, accordingly, only eighteen guttæ in place of thirty-six; that is, three rows, instead of six. There is also a mutule over each metope, as well as one over each triglyph.

56. Vignola gives his denticulated Doric a large cavetto for a cymatium, or gutter, instead of a cyma recta, and supports the echinus of the capital by three fillets, instead of by a fillet and bead, Fig. 26 (*b*).

The triglyphs are three-quarters of a diameter high and half a diameter wide, as shown in Fig. 27. This width is

divided into three parts, called *shanks* or *femurs*. Each shank is beveled on the edge nearly up to the top of the triglyph, making in all two channels and two half channels. Each shank is one-sixth of a diameter wide and each beveled face a quarter of a sixth. The plain face of the shank is, accord-

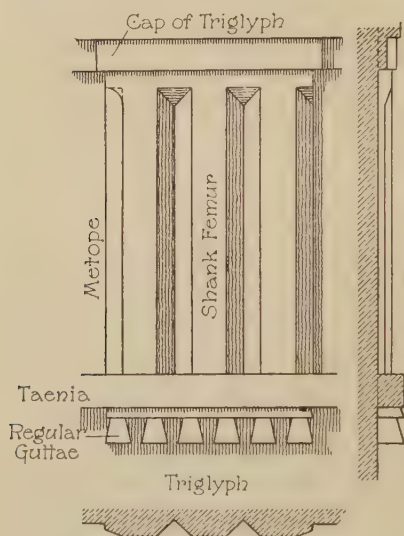


FIG. 27

ingly, one-twelfth, and just as wide as the channel. These are almost the only beveled faces to be found in the whole range of classical architecture, though beveled fillets are not uncommon. The two full channels are generally cut in at an angle of 45° , but the two half channels on either side are shallower, and do not reach the face of the frieze.

The triglyphs come just over the columns. The portion of the frieze between the triglyphs is called a *metope*. It is ex-

actly square, being three-quarters of a diameter wide. The fragment of a metope between the last triglyph and the corner of the frieze is one-sixth of a diameter wide. The face of the metopes comes over the lower band of the architrave, and that of the triglyph projects slightly beyond the face of the upper band.

The column is eight diameters in height, the base, capital, and architrave each half a diameter, and the frieze and cornice each three-quarters. The total projection of the cornice, including the cymatium, is one diameter. The architrave is divided into two bands, or *fasciæ*. The lower one occupies the lower third of the architrave, and the *tænia*, *regula*, and *guttæ* the upper third. Half of this third goes to the *tænia*, the projection of which equals its height.

57. The Doric column has twenty *channels*, each about one-sixth of a diameter wide, which show in section, Fig. 28, an arc of 60° . The solid edge that separates them, called the *arris*, makes an angle of something over 90° (102°). The ten arrises shown in elevation are easy to draw, as two come on the outline of the shaft, two come on its "corners," and the two middle ones are almost exactly one-sixth of a diameter apart. The channels are .157 of a diameter wide, so that making the middle one one-sixth, or .166, of a diameter involves an error of only .009 of a diameter, or about one-eighteenth of its width. The four other arrises can then be put in without much difficulty.

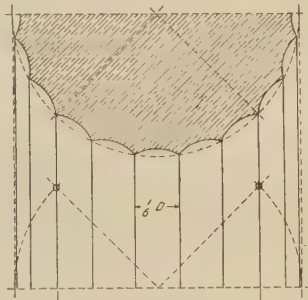


FIG. 28

58. The Doric base and capital, Figs. 25 and 26, are divided, like the Tuscan, into halves and thirds, but with additional moldings, a bead being added above the torus of the base and another below the echinus of the capital. The abacus is crowned by a cymatium consisting of a fillet and cyma reversa. If the height of the capital is divided into thirds, the two upper thirds again into thirds, and the upper and lower of these still again into three equal parts, all the horizontal lines of the capital will be determined, as shown in Plate VI.

Vignola's denticulated Doric is imitated closely from the Doric order of the Theater of Marcellus, and the mutulary Doric, which he has been credited with inventing, seems to have been derived from the Doric order of the Basilica Julia. There are no Roman Doric temples.

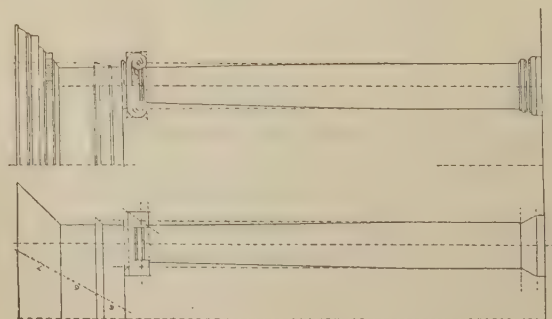
TABLE OF THE DORIC ORDER

	{	height of frieze.
	{	height of cornice.
$\frac{3}{4} D$ equals	{	projection of corona (denticulated).
	{	projection of mutule (mutulary).
	{	width of metope.
$\frac{1}{4} D$ equals		height of plinth.
	{	projection of plinth.
	{	projection of abacus.
	{	height of abacus.
	{	height of necking.
$\frac{1}{6} D$ equals	{	height of echinus and bead.
	{	height of lower band.
	{	height of guttæ, regula, and tænia.
	{	width of shank.
	{	width of corrie metope.
$\frac{1}{2} D = \frac{3}{6} D$ equals	{	height of base, including the cincture.
	{	height of capital.
	{	height of architrave.
	{	width of triglyph.
$\frac{1}{8} D$ equals		height of dentils.
	{	width of dentils.
$\frac{1}{12} D$ equals	{	height of tænia.
	{	projection of tænia.
$\frac{1}{16} D$ equals	{	height of astragal.
	{	projection of astragal.
$\frac{1}{24} D$ equals		width of interdentils.

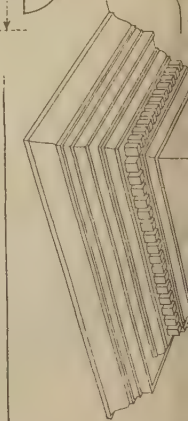
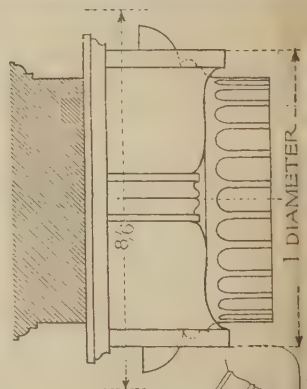
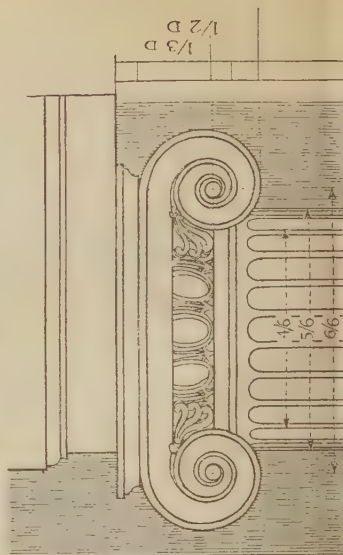
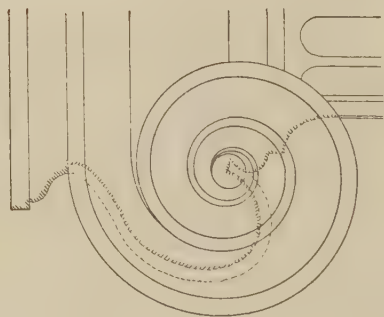
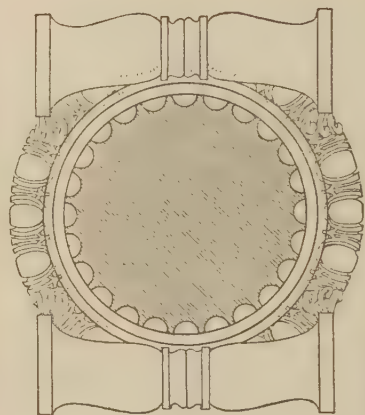
IONIC ORDER—PLATES VII AND VIII

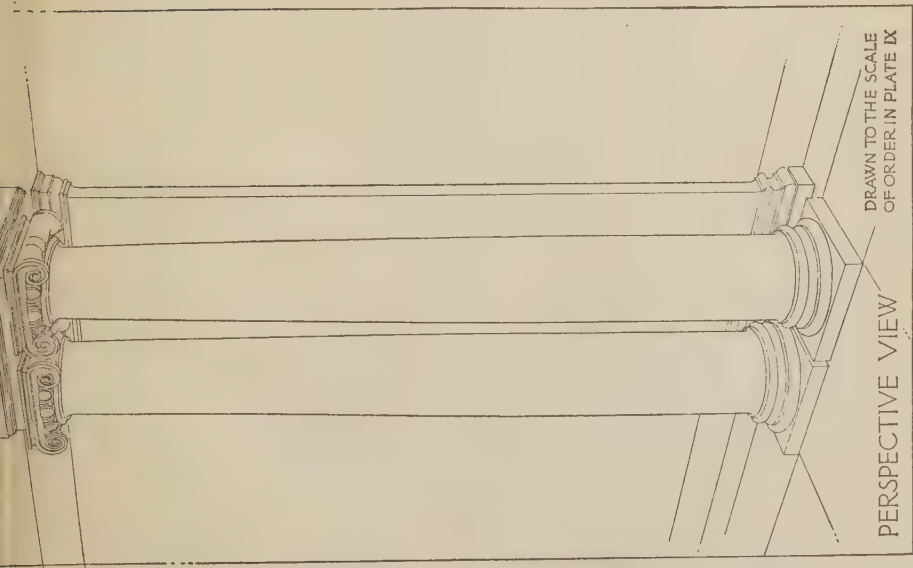
59. The prototypes of the **Ionic order** are to be found in Persia, Assyria, and Asia Minor (see Fig. 33, *History of Architecture and Ornament*, Part 1). Like the Doric order, it seems to have originated in a wooden construction. It is characterized by bands in the architrave and dentils in the

IONIC ORDER

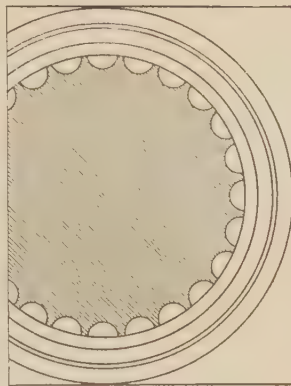
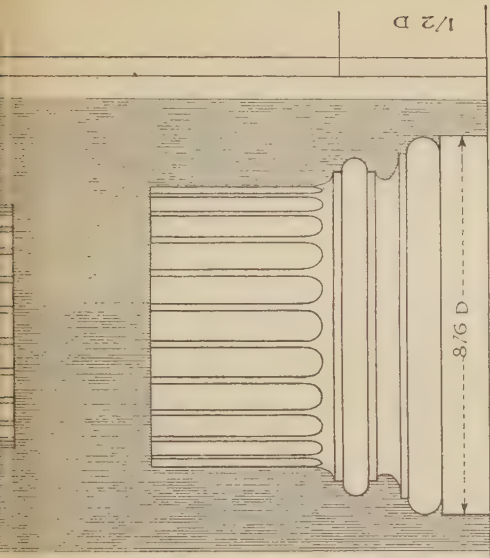
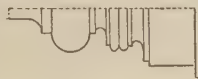


PLAN OF CAPITAL

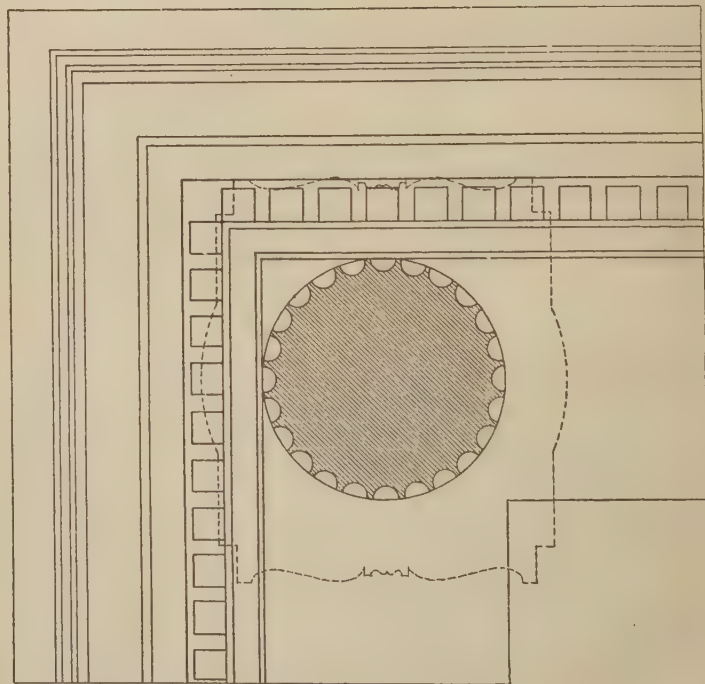




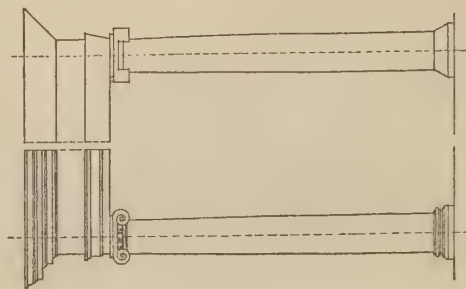
VIGNOLA'S
BASE



IONIC ORDER

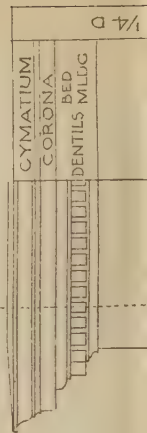


PLAN of ENTABLATURE LOOKING UP

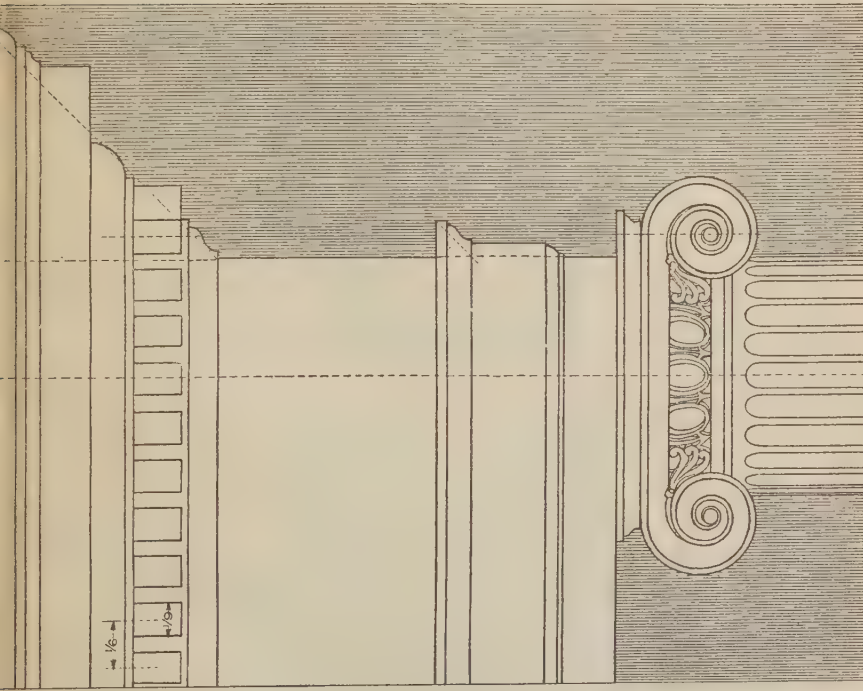


BLOCK ORDER

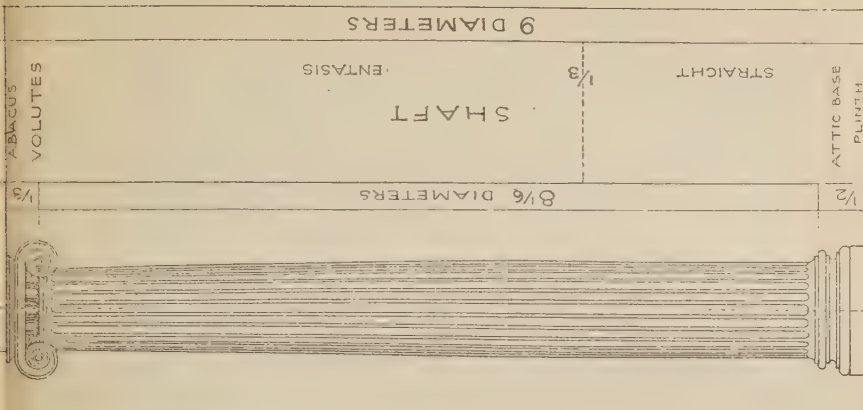
COMPLETE ORDER



CORNICE	7/80
FRIEZE	6/80
ARCHITRAVE	5/80
CAPITAL	1/20
	1/8



ELEVATION OF ENTABLATURE



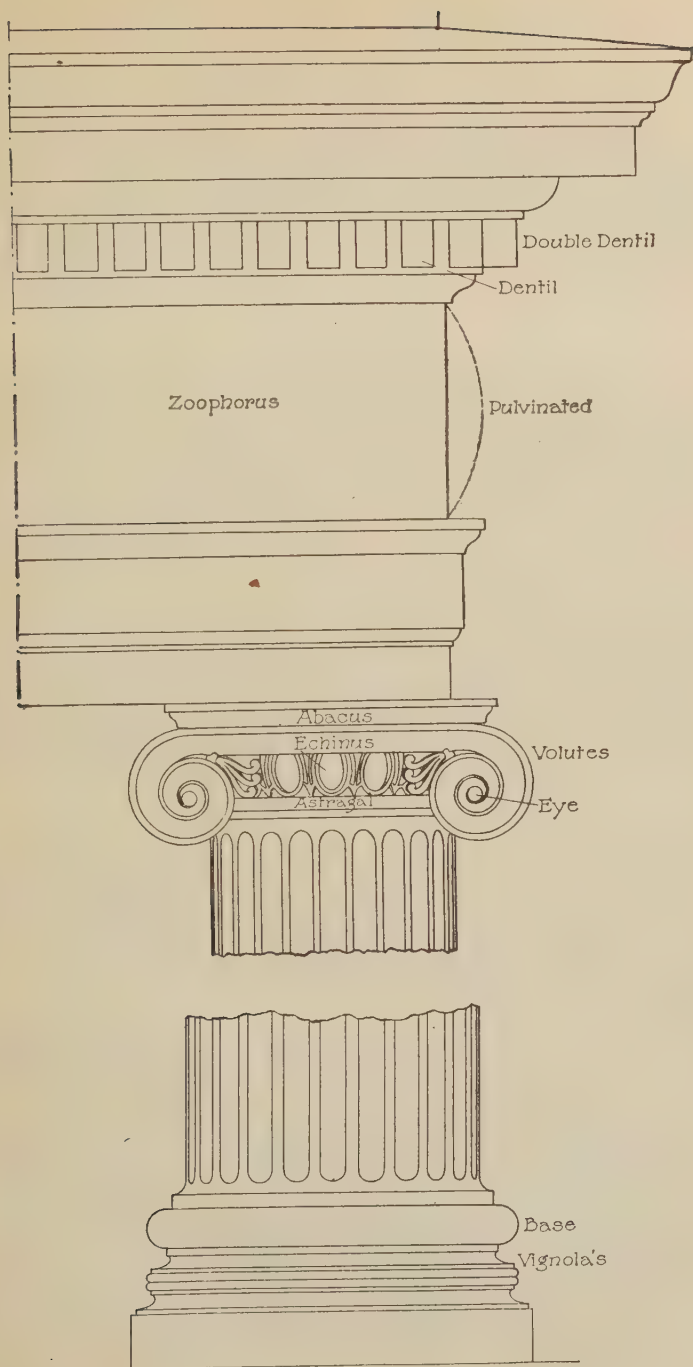


FIG. 29

bed mold, both of which are held to represent sticks laid together to form a beam or a roof. But the most conspicuous and distinctive feature is the *scrolls* that decorate the capital of the column. These have no structural significance, and are purely decorative forms derived from Assyria and Egypt. Originally, the Ionic order had no frieze and no echinus in the capital. These were borrowed from the Doric order, and, in a similar manner, the dentils and bands in the Doric were imitated from the Ionic. The Ionic frieze was introduced in order to afford a place for sculpture, and was called by the Greeks the *Zoöphorus*, or figure bearer, Fig. 29.

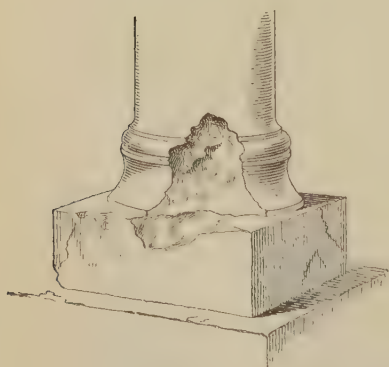
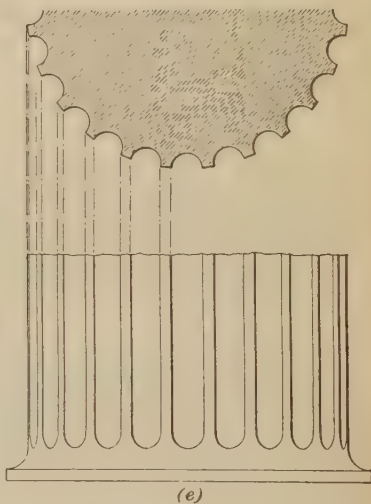
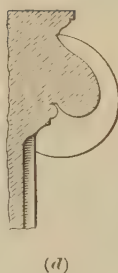
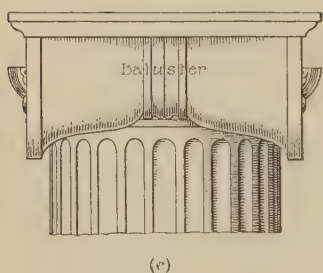
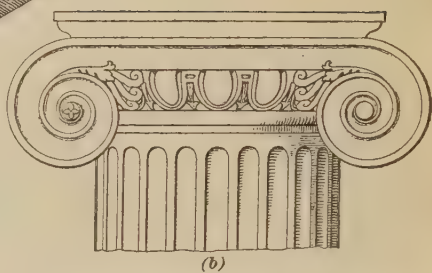
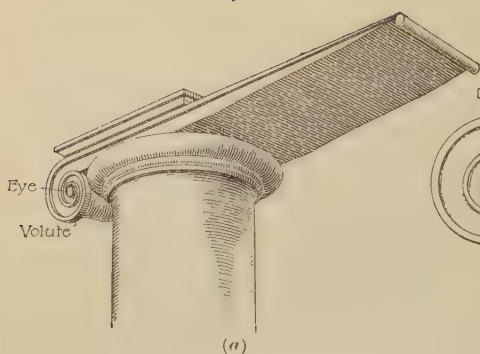
60. In the Ionic entablature, the architrave, frieze, and cornice are of about the same height, each measuring about three-quarters of a diameter. But Vignola makes the architrave a little smaller and the cornice a little larger, so that they measure, respectively, five-eighths, six-eighths, and seven-eighths of a diameter. The architrave is divided into five parts, each an eighth of a diameter in height. The upper one is occupied by a large cyma reversa and a fillet, which take the place of the Doric *tænia*. Below are two fasciæ, or bands, of equal height, each measuring a quarter of a diameter. The lower one is crowned by an ovolo and fillet. The French often use three bands, as in the Corinthian architrave.

The Ionic frieze is plain, except for the sculpture on it. It sometimes has a curved outline, as if ready to be carved, and is then said to be *pulvinated*, from *pulvinar*, a bolster, which it much resembles.

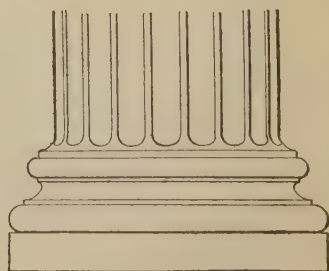
61. The cornice is much like that of the denticulated Doric, which was derived from it, but has no mutules. The upper half, as in the Doric, is taken up by the cymatium and corona, and the lower half by the bed mold. This is divided into four equal parts, of which the upper one is given to an ovolo, the lower to a cyma reversa and fillet, and the two middle ones to a dentil band and fillet. On this band are planted the dentils, which are one-sixth of a diameter high, and are set one-sixth on centers, or on edges, instead of one-

eighth, as in the denticulated Doric. Two-thirds of this sixth go to the width of the dentil and one to the space between, or interdental. The dentil is, accordingly, one-ninth of a diameter wide, and the interdental one-eighteenth, instead of a twelfth and a twenty-fourth. A dentil is put on the axis of a column, and an interdental comes just over the outer line of the frieze. There is, apparently, a double dentil on the corner, the outer face of which is two-thirds of a diameter, or four-sixths, from the axis of the column. The first half of it, as in the denticulated Doric, comes over the outer face of the lower end of the shaft (see Fig. 42). There are two dentils between the one over the column and the double dentil, in place of three, as in the Doric.

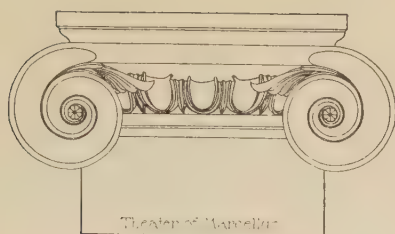
62. The Ionic capital, like the Doric, has an echinus and an abacus crowned by a *cyma reversa* and fillet. But generally it has no necking, and it is, accordingly, only two-sixths of a diameter in height, or one-third instead of one-half. Both the echinus and the cymatium that crown the abacus are larger than in the Doric, and the face of the abacus smaller, and the echinus projects in front of the abacus, instead of being covered by it. The abacus and its fillet extend beyond the echinus on either side, and are curled up into the scrolls, or *volute*s, as shown in Fig. 30 (*a*), the whole height of which is a half diameter, measuring down from the architrave. The *eyes* of the scrolls are one-third of a diameter from the top, on the line separating the bottom of the capital from the top of the astragal that crowns the shaft. They are just one diameter apart on centers, coming over the outer lines of the lower end of the shaft, and the inner edges of the scrolls are two-thirds apart. The echinus is generally carved with eggs and darts, three of which show between the scrolls, the next one on either side being hidden by sprigs of honeysuckle ornament. These scrolls, Fig. 30 (*b*), show on the sides a series of moldings called the *baluster*, or *bolster*, as in (*c*), a section through the center of which is shown in (*d*). The term abacus is generally held to apply only to the *cyma reversa* and fillet, above the scrolls.



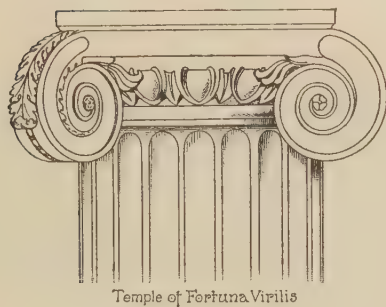
Base of Choragic Column (Athens)
(f)



Attic Base
(g)



(a)



(b)



(c)



(d)

FIG. 31

63. The shaft of the column is ornamented with twenty-four *flutings*, Fig. 30 (*e*), semicircular in section, which are separated not by an arris, but by a fillet of about one-fourth their width. This makes the flutings only about two-thirds as wide as the Doric channels, or about one-ninth of a diameter, instead of one-sixth. Four-fifths of one twenty-fourth of the circumference is .106 of a diameter, while one-ninth of the diameter is .111, a difference of less than a twentieth.

64. The original Greek-Ionic base is considered to have consisted simply of a scotia, and small torus above, as in Fig. 30 (*f*). It is common in modern practice, however, to use instead what is called the *Attic base*, Fig. 30 (*g*), consisting of a scotia and two fillets between two large toruses, mounted on a plinth, the whole being half a diameter high. The plinth occupies the lower third, or one-sixth of a diameter. Vignola adopted for his Ionic order a modification of the Attic base, substituting for the single large scotia two small ones, separated by one or two beads and fillets and omitting the lower torus, as shown in Fig. 29.

65. The principal ancient examples of the Ionic order in Rome are those of the Theater of Marcellus and the Temple of Fortuna Virilis, as shown respectively in Fig. 31 (*a*) and (*b*) and in Figs. 72 and 84, *History of Architecture and Ornament*, Part 1. The Ionic capital sometimes has a necking like the Doric, which is then generally decorated, as in Fig. 31 (*c*). Sometimes, also, the four faces of the capital are made alike, double scrolls occurring at the corners, where they project at an angle of 45°. In this case there is no baluster, and the capital resembles the upper portion of a Composite capital. It is then sometimes called the Roman Ionic capital, or the Scamozzi capital, Fig. 31 (*d*), from the name of the architect Scamozzi, who frequently employed it.

Almost all the dimensions of the Ionic order can be expressed in terms of sixths of a diameter, as appears in the following table:

TABLE OF THE IONIC ORDER

$\frac{5}{8} D$ equals height of architrave.

$\frac{3}{4} D = \frac{6}{8} D$ equals height of frieze.

$\frac{7}{8} D$ equals $\left\{ \begin{array}{l} \text{height of cornice.} \\ \text{projection of cornice.} \end{array} \right.$

$\frac{1}{4} D = \frac{2}{8} D$ equals height of each band.

$\frac{1}{6} D$ equals $\left\{ \begin{array}{l} \text{projection of plinth.} \\ \text{height of plinth.} \\ \text{height of dentils.} \\ \text{distance of dentils, o. c.} \\ \text{projection of abacus.} \end{array} \right.$

$\frac{1}{3} D = \frac{2}{6} D$ equals height of capital.

$\frac{1}{2} D = \frac{3}{6} D$ equals $\left\{ \begin{array}{l} \text{height of base.} \\ \text{height of scrolls.} \end{array} \right.$

$\frac{2}{3} D = \frac{4}{6} D$ equals $\left\{ \begin{array}{l} \text{distance between scrolls.} \\ \text{distance from axis to outer face of} \\ \text{double dentil.} \end{array} \right.$

$\frac{5}{8} D$ equals upper diameter.

$1 D = \frac{6}{6} D$ equals $\left\{ \begin{array}{l} \text{lower diameter.} \\ \text{distance of eyes of scrolls, o. c.} \\ \text{length of baluster.} \end{array} \right.$

$\frac{7}{8} D$ equals width of abacus.

$1\frac{1}{3} D = \frac{8}{6} D$ equals $\left\{ \begin{array}{l} \text{width of plinth.} \\ \text{width of echinus (minus).} \end{array} \right.$

$1\frac{1}{2} D = \frac{9}{6} D$ equals width of scrolls (minus).

$\frac{1}{9} D$ equals $\left\{ \begin{array}{l} \text{width of dentil.} \\ \text{width of fluting.} \end{array} \right.$

$\frac{1}{12} D$ equals $\left\{ \begin{array}{l} \text{height of astragal.} \\ \text{projection of astragal.} \end{array} \right.$

$\frac{1}{18} D$ equals width of interdental.

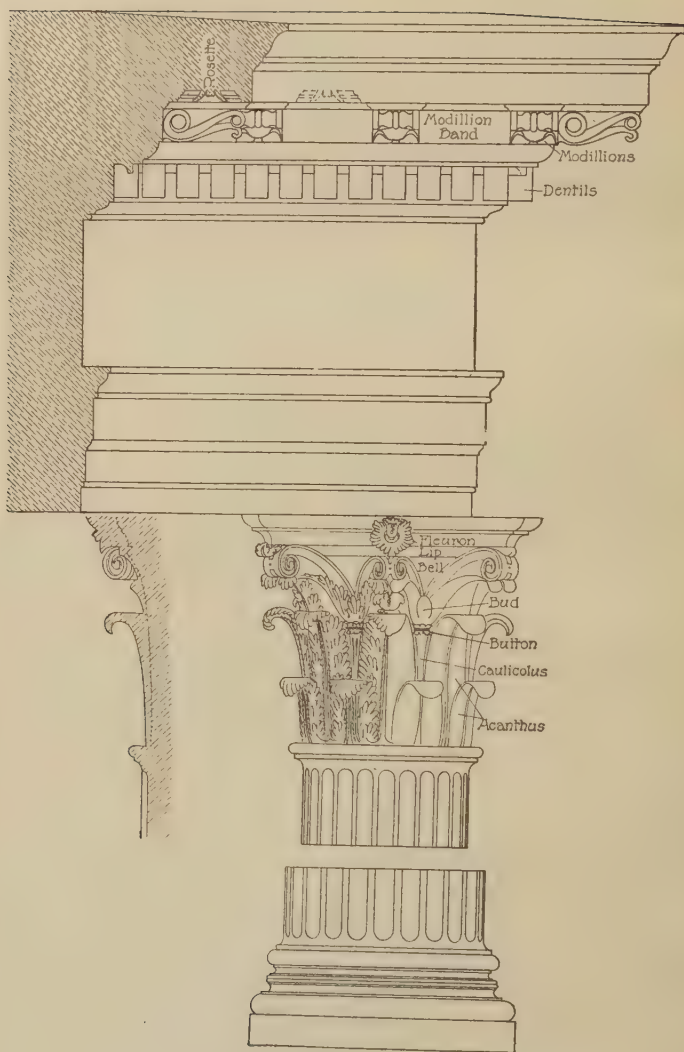
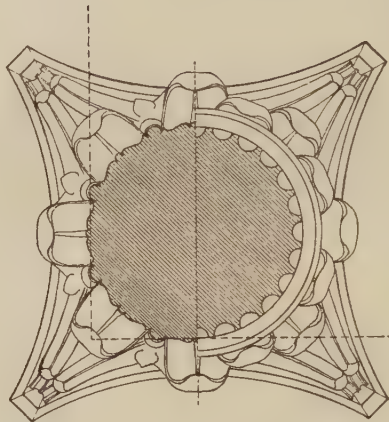
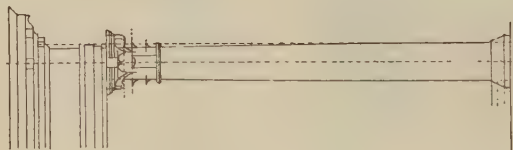
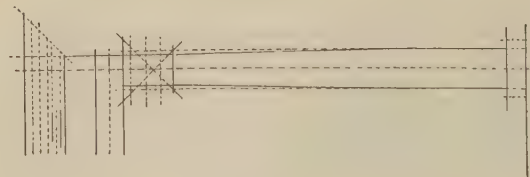
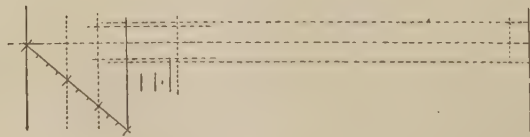


FIG. 32

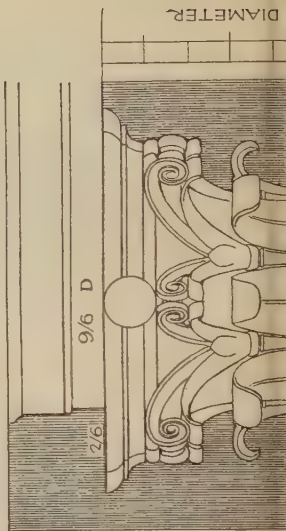
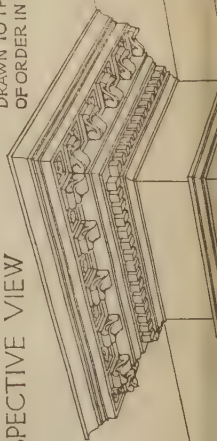
CORINTHIAN ORDER



PLAN OF CAPITAL LOOKING UP

PERSPECTIVE VIEW

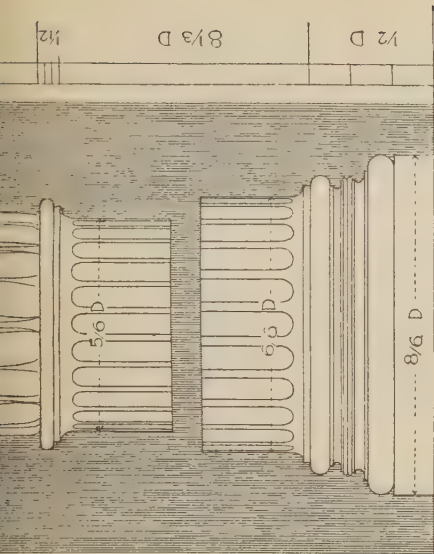
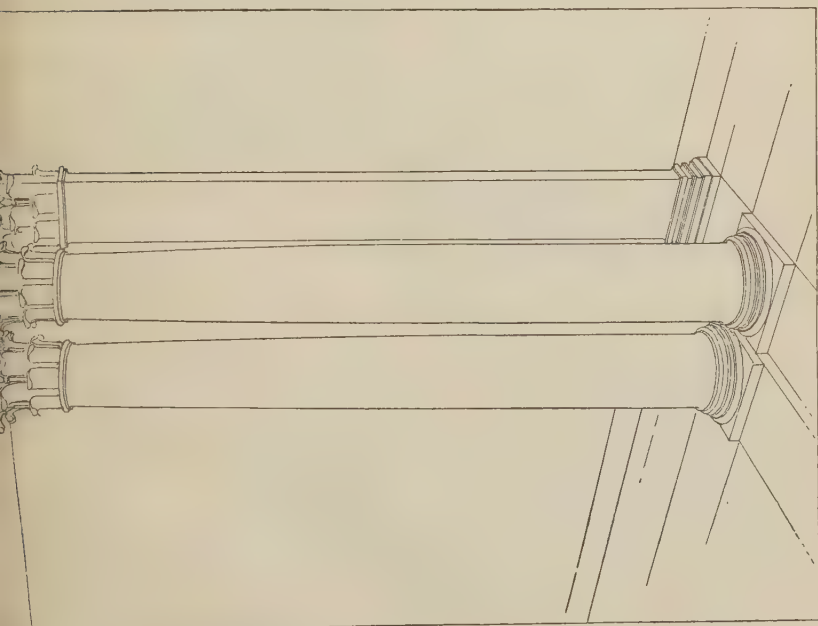
DRAWN TO THE SCALE
OF ORDER IN PLATE XI



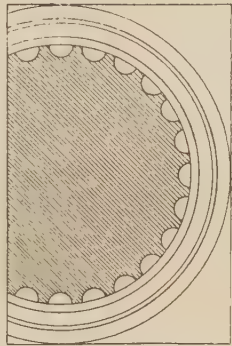
DIAMETER

$\frac{9}{6}$ D

$\frac{2}{6}$

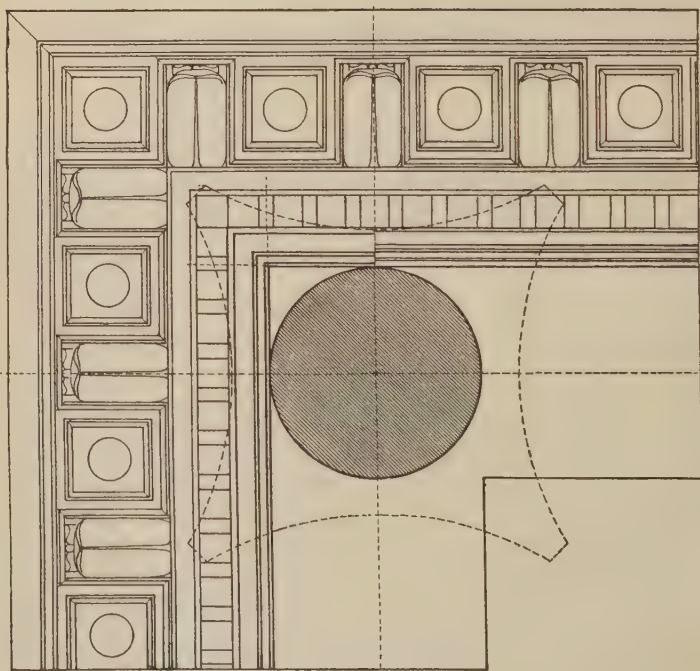


ELEVATION OF CAPITAL AND BASE

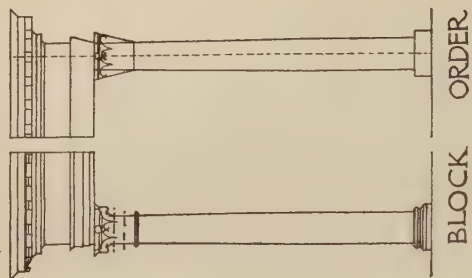


PLAN OF BASE

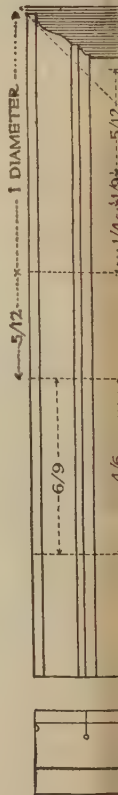
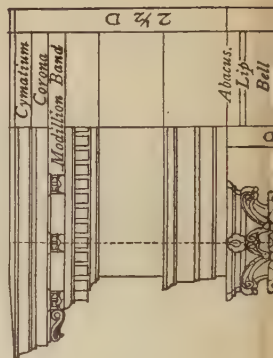
CORINTHIAN ORDER

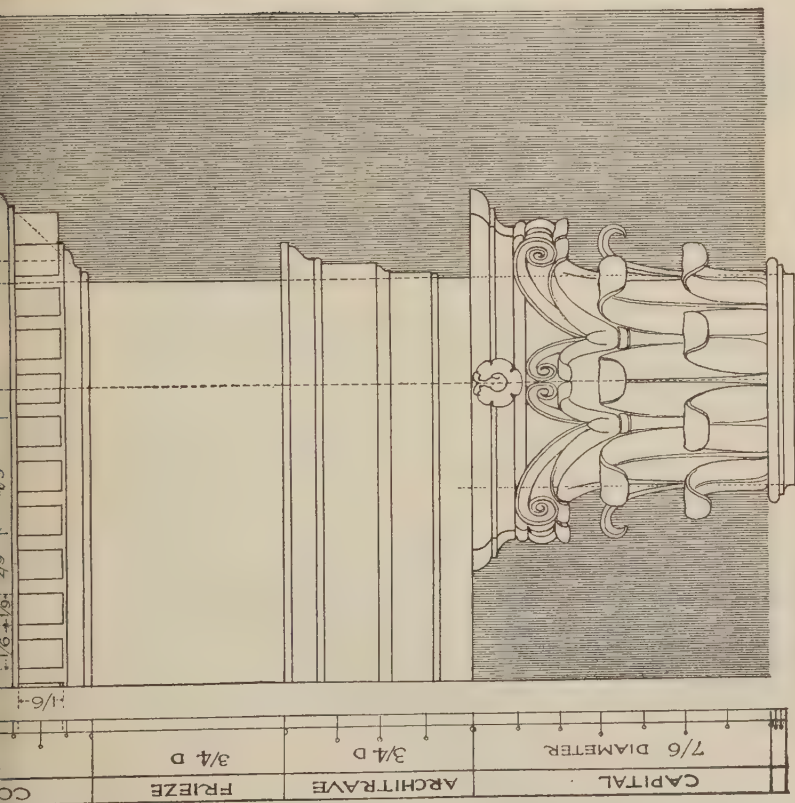


PLAN OF ENTABLATURE LOOKING UP

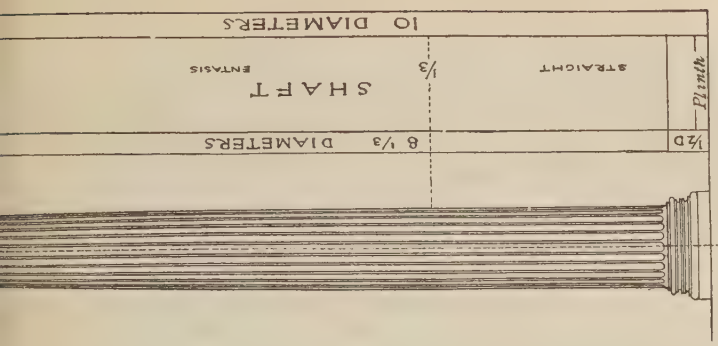


COMPLETE ORDER





ELEVATION OF ENTABLATURE



CORINTHIAN ORDER—PLATES IX AND X

66. The three distinguishing characteristics of the **Corinthian order**, Plates IX and X, are a tall bell-shaped capital, a series of small brackets, called *modillions*, that support the cornice instead of mutules, in addition to the dentils, and a general richness of detail in both capitals and modillions, which is enhanced by the use of the *acanthus leaf* (see *History of Architecture and Ornament*, Part 1).

The height of the cornice, Fig. 32, is divided into five parts. The two lower and the two upper parts resemble the lower and upper halves of the Ionic cornice. The middle fifth is occupied by a *modillion band*, which carries the modillions, or brackets. These, as well as the modillion band, are crowned by a small *cyma reversa*. They consist of a double scroll, below which is an *acanthus leaf*. Each modillion is half a diameter long, one-fifth high, and as wide as a dentil and two interdentils; that is to say, two-ninths of a diameter. They are set two-thirds of a diameter on centers, one being over the axis of the corner column, and one over the outer face of the double dentil. The soffit of the corona between the modillions is occupied by a sinkage with moldings, called a *caisson*, in the middle of which there is a large *rosette*.

As the modillions are two-thirds of a diameter on centers, or four-sixths, and the dentils are one-sixth on centers, it follows that there are four dentils to each modillion; that is, a dentil under every modillion, and three between. As in the Ionic order and in the denticulated Doric, the last dentil, which is the first half of the double dentil, is centered over the face of the lower diameter of the column, as shown in Fig. 74 (c).

67. The architrave, which is three-quarters of a diameter high, has three bands and a large cymatium, which is as wide as the first band. The two lower bands occupy the lower half of the architrave, and the third band and the cymatium the upper. A small bead, or a small *cyma reversa*, generally,

crowns each band. The frieze, which is also three-quarters of a diameter high, may be plain, pulvinated, or sculptured.

68. The capital is seven-sixths of a diameter high, the upper sixth being taken up by the abacus, which is nine-sixths, or a diameter and a half, in width, though it does not look so. It is molded on the edge with an ovolo and fillet above a large congé and small fascia. The corners are cut off at an angle of 45° , and the sides are hollowed out in a curve of 60° , as shown in Fig. 33 (a). The width across from curve to curve is seven-sixths of a diameter. Each face of the abacus bears a flower, called the *fleuron*, that springs from a small bud above the middle leaf.

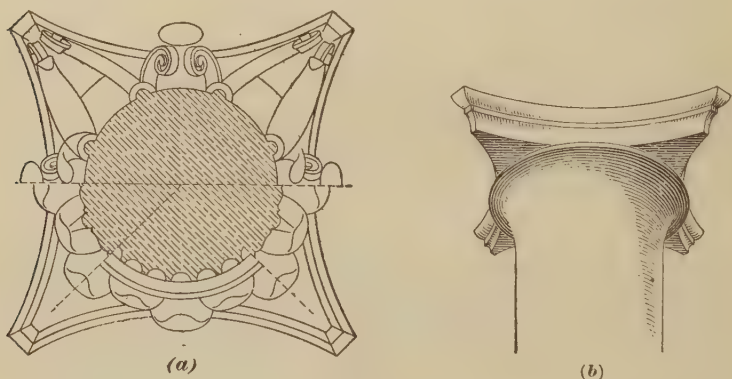
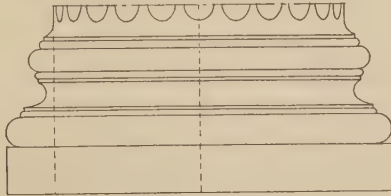


FIG. 33

The *bell* of the capital, Fig. 33 (b), is one diameter high, or six-sixths; it terminates under the abacus in a beak molding called the *lip of the bell*, which measures seven-sixths of a diameter across, its greatest projection coming just under the least projection of the upper line of the abacus. The lower two-sixths are covered by a row of eight acanthus leaves that bend down at the top to the extent of half a sixth, or a quarter of their own height. The next two-sixths show a similar row of eight leaves set alternately with those below, four facing the sides of the capital, and four the corners. Like those of the first row, they spring from the astragal at the top of the shaft, and the mid-rib of each

leaf shows between two lower leaves, it being really four-sixths high. These also bend down half a sixth. Between the eight leaves of the second row are eight *caulicoli*, or cabbage stalks, which terminate in a *button*, on which rests a sort of *bud*, which divides into two leaves. These turn right and left, the larger one toward the corner of the capital, the smaller toward the side or front under the fleuron. From each bud rise also two scrolls, or volutes, one of which runs out to support the projecting corner of the abacus. The other, which is smaller and does not rise higher than the lip of the bell, supports the fleuron. Sixteen leaves of a third row curl over under these sixteen volutes, making with them eight masses of ornament, one under each corner of the abacus, and one in the middle of each side. These give in



Palladio's Corinthian Base

FIG. 34

plan an eight-pointed star, each point consisting of a large leaf, two small leaves, two volutes, and above them either the fleuron or the horn of the abacus. Between them is seen the bell of the cap, with its lip.

69. Here, again, the Attic base is commonly used, but sometimes, especially in large columns, a base is used that resembles Vignola's Ionic base, with two beads between the scotias, except that it has a lower torus, as shown in Fig. 33. Palladio used a very elegant variety of Attic base, enriched by the addition of beads and fillets, as shown in Fig. 34. The shaft is fluted like the Ionic shaft, with twenty-four semicircular flutings, but these are sometimes filled with a convex molding, or *cable*, to a third of their height.

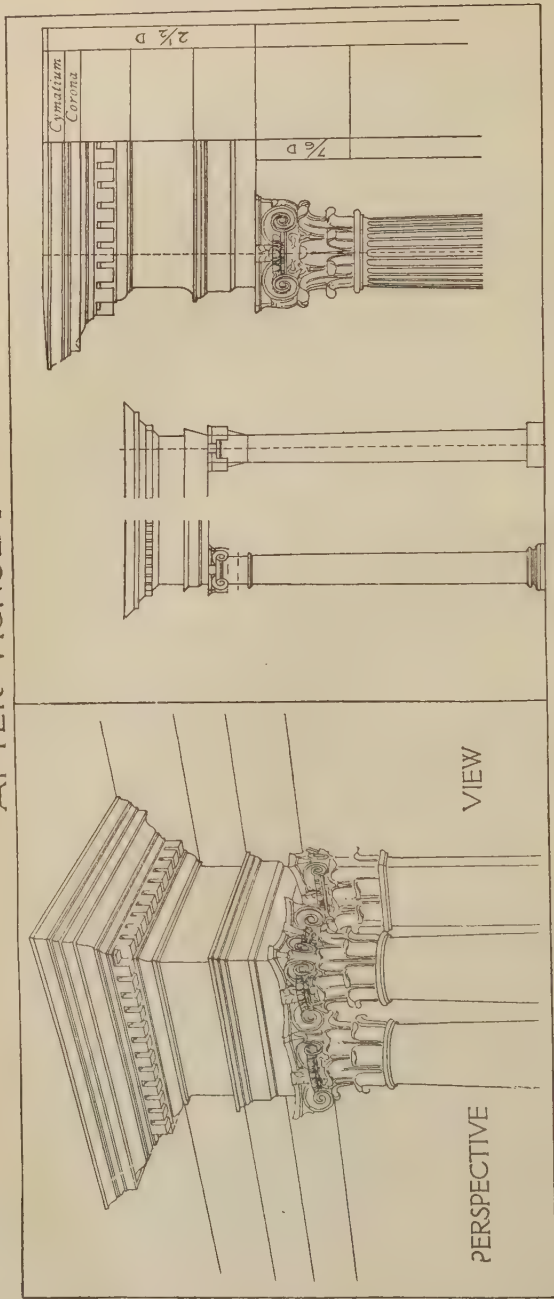
Almost all the buildings erected by the Romans employ the Corinthian order.

TABLE OF THE CORINTHIAN ORDER

$\frac{3}{4} D$ equals	{	height of architrave.
	}	height of frieze.
$1 D = \frac{4}{4} D$ equals	{	height of cornice.
	}	projection of cornice.
$\frac{1}{6} D$ equals	{	projection of plinth.
	}	height of plinth.
	}	height of lower band.
	}	height of dentils.
	}	distance of dentils, o. c.
$\frac{1}{3} D = \frac{2}{6} D$ equals	{	height of leaves.
	}	projection of abacus.
$\frac{1}{2} D = \frac{3}{6} D$ equals		length of modillions.
$\frac{2}{3} D = \frac{4}{6} D$ equals	{	distance of modillions, o. c.
	}	distance from axis to face of double dentil.
$\frac{5}{6} D$ equals		upper diameter.
$1 D = \frac{6}{6} D$ equals	{	lower diameter.
	}	height of bell.
	}	height of cornice.
	}	projection of cornice.
$\frac{7}{6} D$ equals	{	height of capital.
	}	width of abacus (least).
	}	width of lip of the bell.
$1\frac{1}{3} D = \frac{8}{6} D$ equals		width of plinth.
$1\frac{1}{2} D = \frac{9}{6} D$ equals		width of abacus (greatest).
$2 D = \frac{12}{6} D$ equals		width of abacus (diagonal).
$\frac{1}{9} D$ equals		width of dentil.
$\frac{2}{9} D$ equals		width of modillion.
$\frac{1}{18} D$ equals		width of interdental.
$\frac{1}{12} D$ equals	{	height of astragal.
	}	projection of astragal.
$\frac{1}{6} D$ equals		height of modillion.

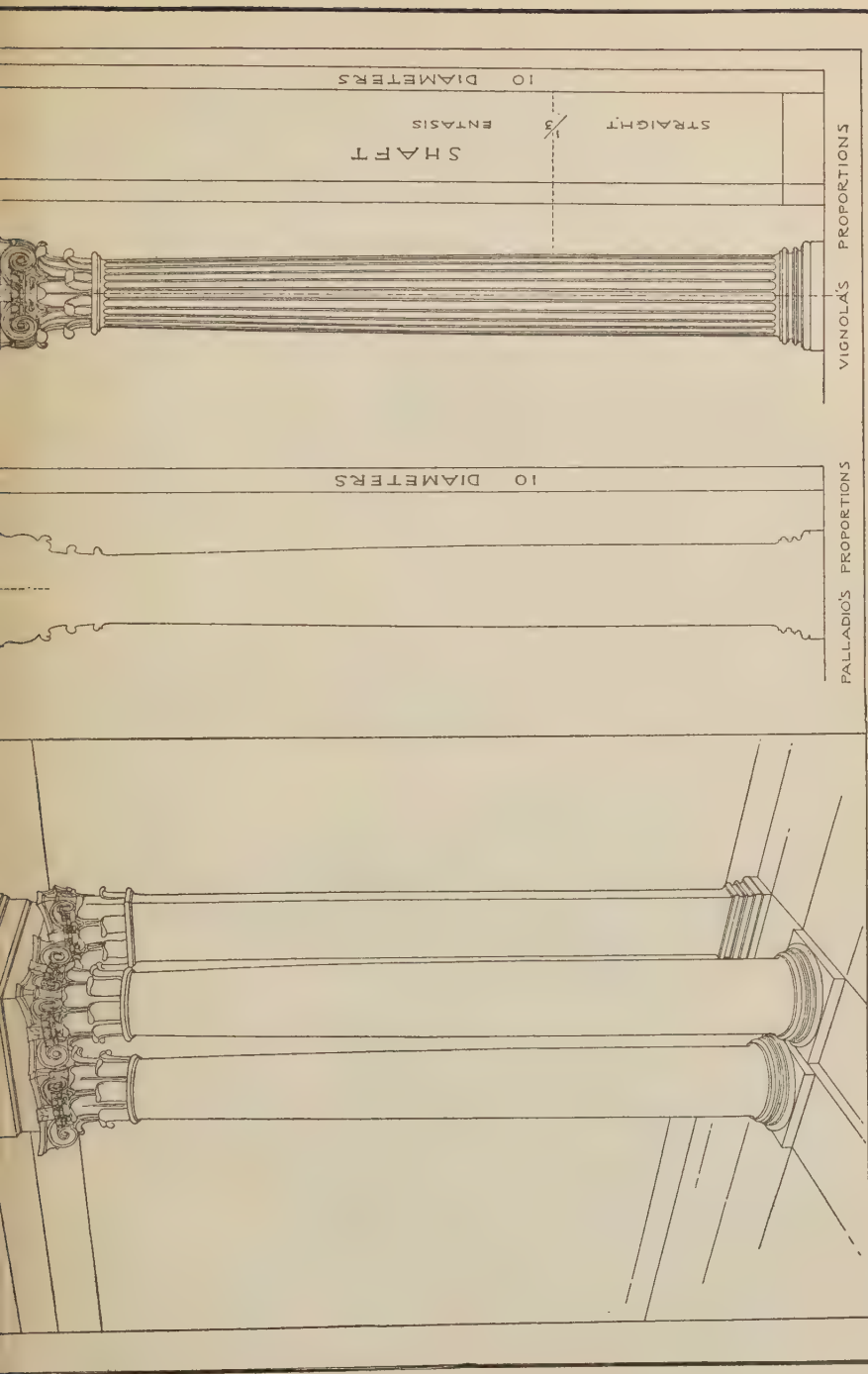
COMPOSITE ORDER

AFTER VIGNOLA

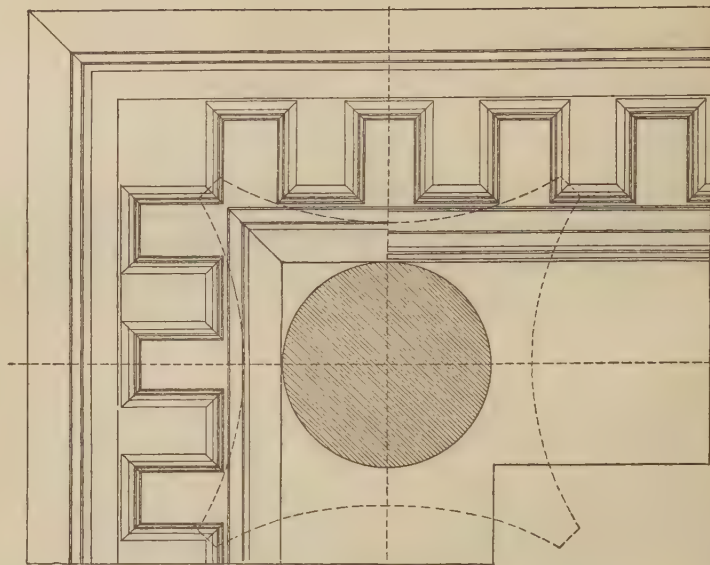
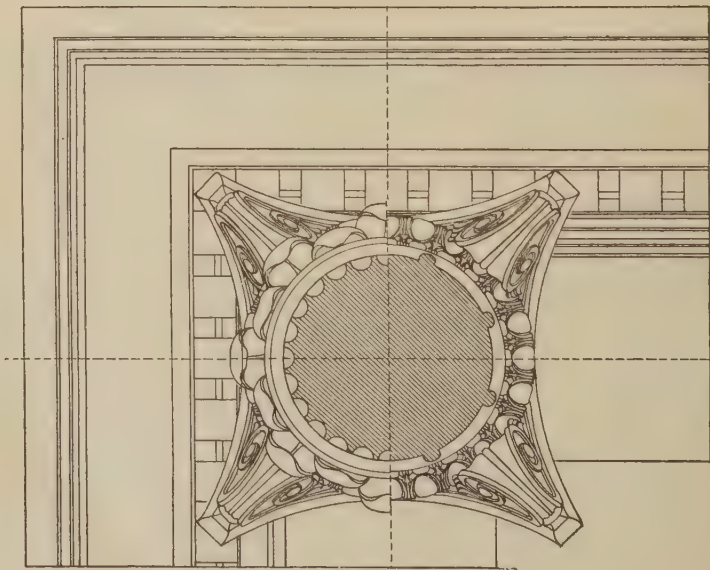


AFTER PALLADIO

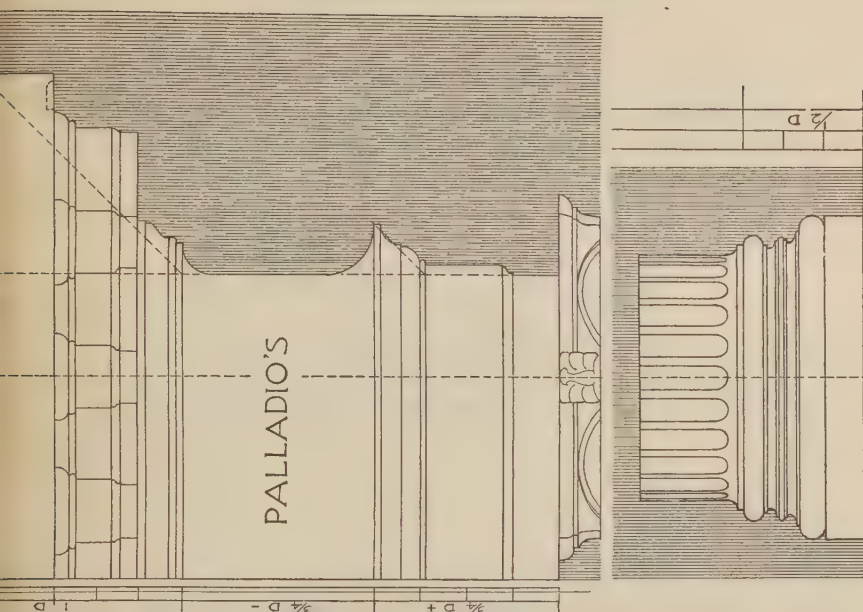
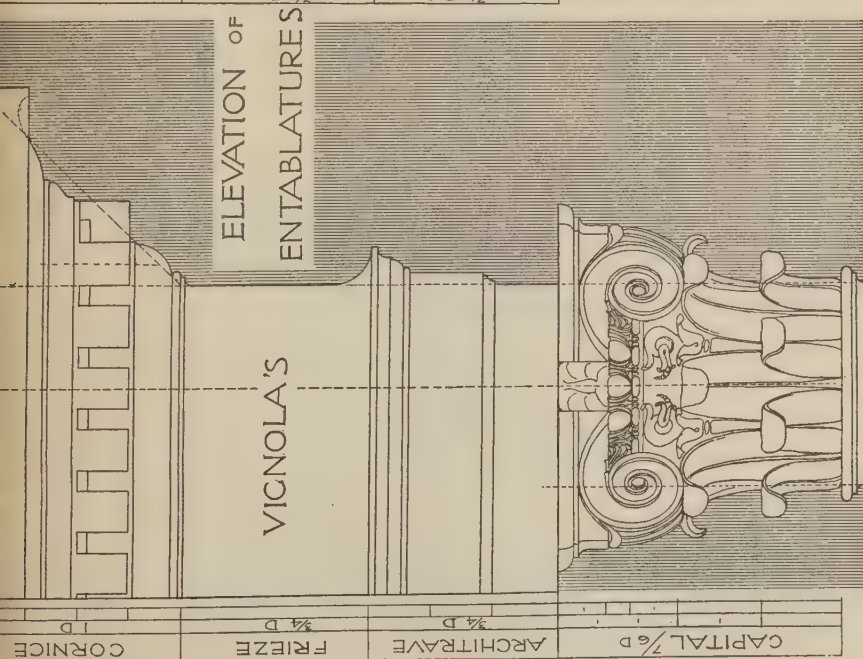




COMPOSITE ORDER



PLAN of ENTABLATURES LOOKING UP



COMPOSITE ORDER—PLATES XI AND XII

70. The Composite order, Fig. 35, is a heavier Corinthian, just as the Tuscan is a simplified Doric. The chief

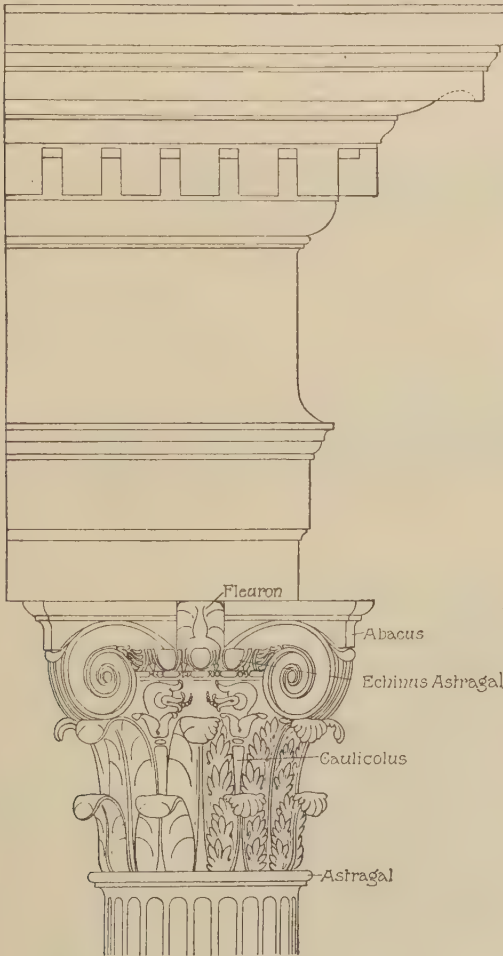


FIG. 35

proportions are the same as in the Corinthian order, but the details are fewer and larger. It owes its name to the capital, Fig. 35, in which the two lower rows of leaves and the

caulicoli are the same as in the Corinthian. But the caulicoli carry only a stunted leaf bud, and the upper row of leaves and the sixteen volutes are replaced by the large

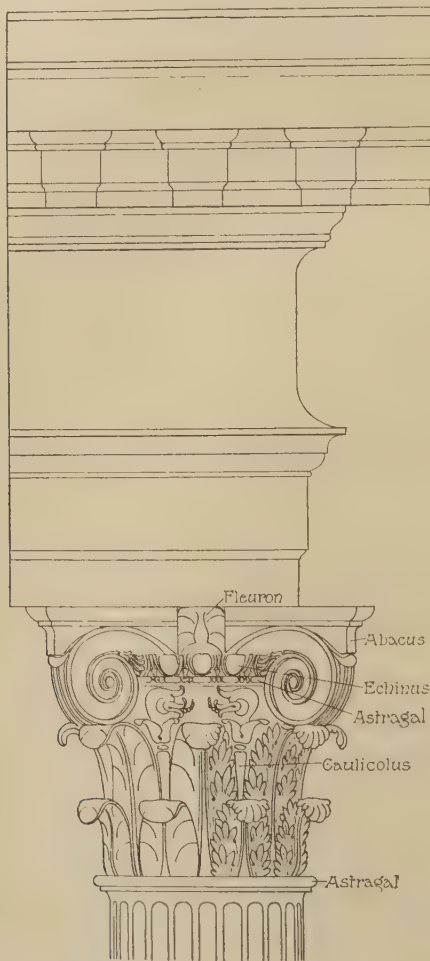


FIG. 36

scrolls, echinus, and astragal of a complete Ionic capital, with four faces like Scamozzi's, Fig. 31 (*d*). A composite capital thus has two astragals, if the lower be included, but

this properly belongs to the shaft. The scrolls are nearly half a diameter high, covering up half the abacus and coming down so as to touch the second row of acanthus leaves. They measure fully nine-sixths across, and are only three-sixths apart, or half a diameter, instead of four-sixths, as in the Ionic.

71. Vignola's composite entablature, Fig. 36, differs from his Ionic chiefly in the shape and size of the dentils. They are larger, and are more nearly square in elevation, being a fifth of a diameter high, and one-sixth wide, the interdentil being one-twelfth, and they are set one-fourth of a diameter apart, on centers. The last dentil, or first half of the double dentil, is centered over the outer face of the column, at the bottom, as in the Corinthian, Ionic, and denticulated Doric, Fig. 42. The outer face of the double dentil is three-quarters of a diameter from the axis of the column, and there is only one dentil between the double dentil and the one over the axis, against two in the Corinthian and Ionic, and three in the denticulated Doric. The frieze terminates in a large congé over the architrave, and the corona is undercut with a large quirked cyma recta, making a drip.

72. Palladio's Composite entablature, Fig. 36, is more characteristic than Vignola's, the parts being fewer and larger. The architrave has two bands, the frieze terminates in two large congés, and the cornice is divided into two equal parts, each half a diameter high. The upper half is shared about equally by the cymatium and the corona, and the lower half is almost entirely taken up by a series of large brackets, or blocks, a third of a diameter high and one-fourth wide, divided into two bands. The inner face of the double block comes just in line with the frieze below, as shown in Fig. 47. The bands and moldings that decorate the blocks are continued between them.

These dimensions apply the Palladio entablature where it is made of the same size as Vignola's; that is to say, a quarter of the height of the column, or two diameters and a

half. But Palladio himself made his Composite entablature only two diameters high, or one-fifth the length of the column, cutting down the frieze to half a diameter, the architrave to two-thirds, and the cornice to five-sixths. If the dimensions of Palladio's cornice given in the table are, accordingly, taken from the upper diameter of the shaft instead of from the lower, they will exactly conform to Palladio's own usage.

73. The block entablature used by Scamozzi for his Composite order is even less than two diameters in height, and this seems to have been the case also with the entablature of the Olympiæum at Athens, which Palladio is thought to have imitated.

The moldings below the blocks are often made to project more than in Palladio's example. This increases their distance apart, on centers, since one must still come over the axis of the column and the one on the corner must be as far out as the end of these moldings. The blocks also vary considerably in length in different examples.

The upper part of the Composite capital, as has been said, is often used alone as a variety of the Ionic capital.

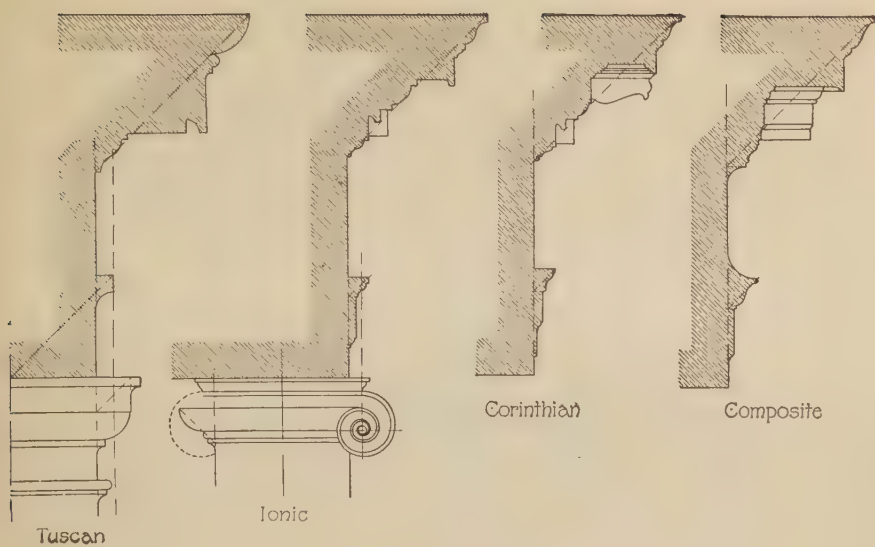
The Composite capital is employed in the Arch of Titus in Rome, and elsewhere, with a Corinthian entablature, and the block cornice occurs in the so-called frontispiece of Nero, as well as in the temple at Athens, in connection with a Corinthian capital.

TABLE OF THE COMPOSITE ORDER

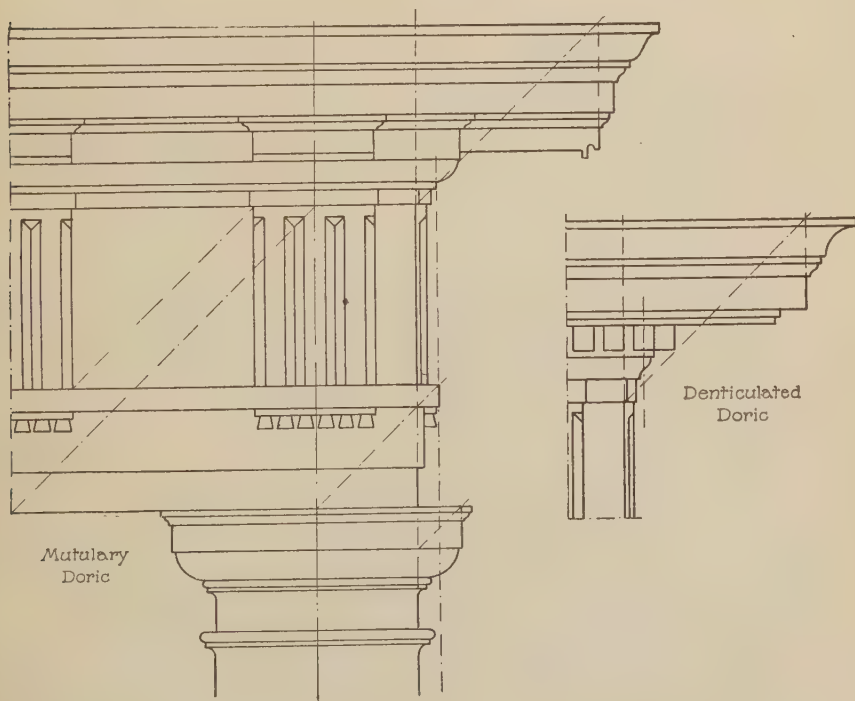
$$\begin{aligned} \frac{1}{2} D = \frac{3}{8} D \text{ equals } & \begin{cases} \text{height of scrolls.} \\ \text{space between scrolls.} \end{cases} \\ \frac{3}{4} D \text{ equals } & \text{distance of eyes, o. c.} \\ 1\frac{1}{2} D = \frac{3}{2} D \text{ equals } & \begin{cases} \text{width of scrolls.} \\ \text{width of plinth.} \\ \text{width of abacus.} \end{cases} \end{aligned}$$

VIGNOLA'S CORNICE

$$\frac{1}{4} D \text{ equals } \begin{cases} \text{height of dentil band.} \\ \text{distance of dentils on centers.} \end{cases}$$



(a)



(b)

FIG. 37

$\frac{3}{4} D$ equals distance from axis to face of double dentil.

$\frac{1}{5} D$ equals height of dentils.

$\frac{1}{6} D$ equals width of dentils.

$\frac{1}{12} D$ equals width of interdental.

PALLADIO'S CORNICE

$\frac{1}{3} D$ equals	{	height of block.
	{	length of block.
	{	width of block.
	{	height of lower band.
$\frac{1}{4} D$ equals	{	height of corona.
	{	height of cymatium.
	{	distance between blocks (plus).

GEOMETRICAL RELATIONS

74. The dimensions and proportions set forth in the preceding paragraphs, and recapitulated in the tables, will enable the draftsman or the designer to draw the five orders, according to Vignola, with great accuracy and sufficiently in detail for all ordinary purposes. The figures for the larger features are easily remembered, and the smaller divisions and subdivisions can for the most part be obtained by dividing the larger into two, three, four, or five equal parts.

But besides these arithmetical proportions some geometrical relations may be pointed out, which are calculated greatly to facilitate the work of draftsmanship, drawing being naturally more closely related to geometry than to arithmetic.

75. Lines at 45 Degrees.—The proportions of any figure that is as wide as it is high, and which can accordingly be included within a square, are most easily determined by drawing the diagonal of the square; that is to say, by drawing a line with a 45° triangle. Such figures are, as is shown in the illustrations, the projections of:

1. The echinus, in the Tuscan, Doric, and Ionic capitals, as in Fig. 37.

2. The abacus, in the Tuscan and Doric capitals.
3. The astragal, in all the orders.

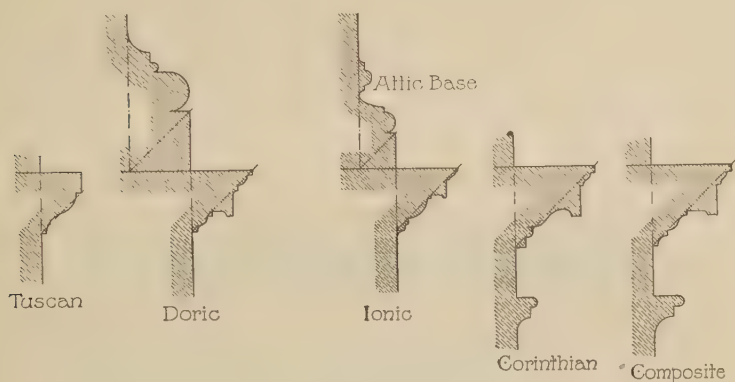


FIG. 38

4. The architrave, including the *tænia*, in the Tuscan and Doric orders, counting from the axis of the column.

5. The *tænia* itself, and the *cymatium* that takes its place.

6. All the cornices, except the Doric.

76. A line drawn at 45° through the Doric cornice from the top of the frieze gives, where it cuts the upper line of the cornice:

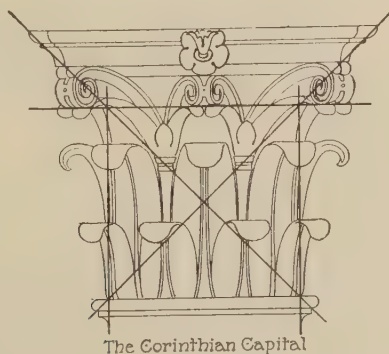


FIG. 39

1. The face of the corona, in the denticulated Doric, as in Fig. 37.

2. The face of the mutule in the mutulary Doric, as in Fig. 37.

A line drawn at 45° through the Doric architrave and frieze, from a point on the axis of the column and of the triglyph, taken either at the bottom of the architrave or at the top of the frieze, gives the axis of the next triglyph, and so on.

A 45° line also gives:

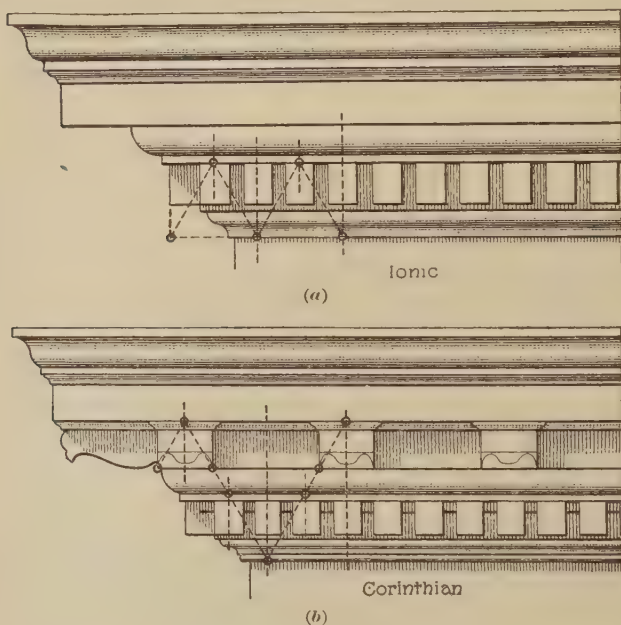


FIG. 40

1. The shape of the metope.
2. The caps of the pedestals, except the Tuscan, as in Fig. 38.
3. The plinths of the Doric and Attic bases.

Lines drawn at an angle of 45° across the Corinthian capital from the extremities of its lower diameter give the width of the abacus, as in Fig. 39.

Where they cut the line of the upper diameter of the shaft, extended, they give the depth of the scroll, as in Fig. 39.

77. Lines at 60 Degrees.—In a similar manner, lines drawn at an angle of 60° through the bed mold of the Ionic cornice from a point on the axis of the column, taken either on the upper line of the frieze or on the upper edge of the dentil band, give, where they touch the upper line of the frieze and the upper line of the dentil band, the axes of the dentils, and the outer face of the double dentil, as shown in Fig. 40 (a).

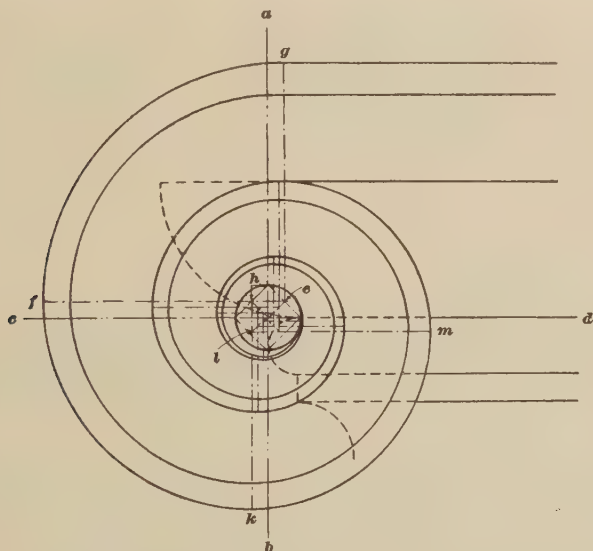


FIG. 41

Similar lines drawn at 60° in the Corinthian cornice, taken from a point where the axis of the column cuts the lower edge of the corona, give: (1) where they cut the lower edge of the corona, the upper line of the frieze, and the lower line of the ovolo, the axes of the modillions and of the dentils, and the outer face of the double dentil, very nearly, as in Fig. 40 (b); (2) where they cut the lower line of the modillion band, the width of the modillion, and the outer face of the modillion band, as in Fig. 40 (b).

The distance from the edge of the corona down to the lower edge of the modillion band is one-third the distance

down to the top of the frieze, and the distance down to the lower edge of the ovolo, one-half.

78. Ionic Volute.—The vertical line ab , Fig. 41, through the center of the eye of the Ionic volute, and the horizontal line cd , will mark in the circumference of the eye the four corners of a square within which a fret may be drawn whose angles will serve as centers, from which the curves of the volute may be described mechanically. The sides of the square should be bisected, and through the upper points thus located a horizontal line ef should be drawn. Now, with eg as a radius, the arc gf may be drawn as the first section of the volute. Now, through the point h , where the line ef bisects the side of the square, a vertical line hk should be drawn, and with hf as a radius the arc fk may be struck. From h and e lines should be drawn at 45° , intersecting at the center of the eye, and the line extending from h to the center should be divided into three equal parts, through which the corners of the inscribed fret will turn. The point l on the line hk , marking the lower left-hand corner of the inscribed fret, is located five-sixths of the distance between h and the point where hk bisects the lower side of the square. The point l then forms the center for the arc km , and the rest of the volute is described from centers found at the angles of the inscribed fret.

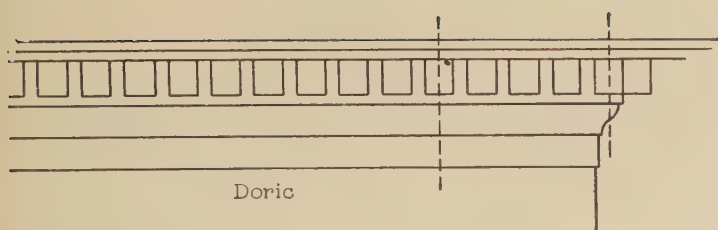
79. Vertical Lines.—The outer line of the upper diameter of the shaft gives, in all the orders, Fig. 37, the face of the lower band of the architrave, and the face of the frieze.

In the denticulated Doric, it gives, as in Fig. 37, the outer face of the first dentil, next the double dentil.

In the Ionic and Corinthian orders, it gives the axis of the first interdentil.

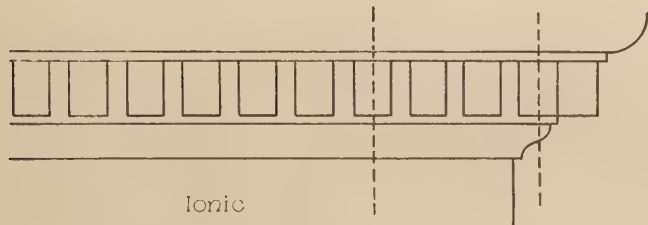
The outer line of the lower diameter of the shaft, produced upwards, gives, as in Fig. 37:

1. The projection of the astragal, in all the orders, except the Tuscan and Doric.
2. The projection of the tænia, in the Tuscan and Doric.



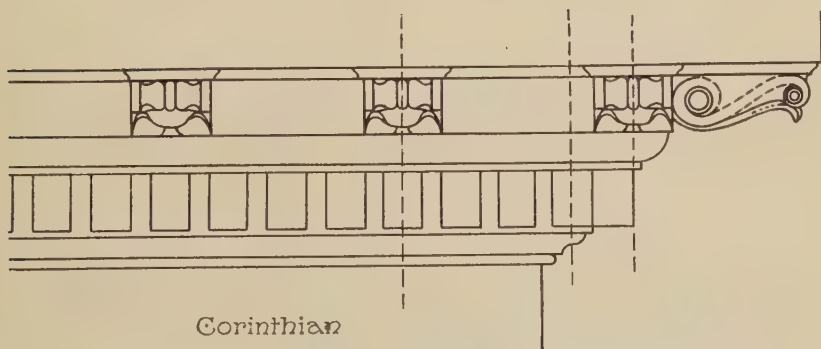
Doric

(a)



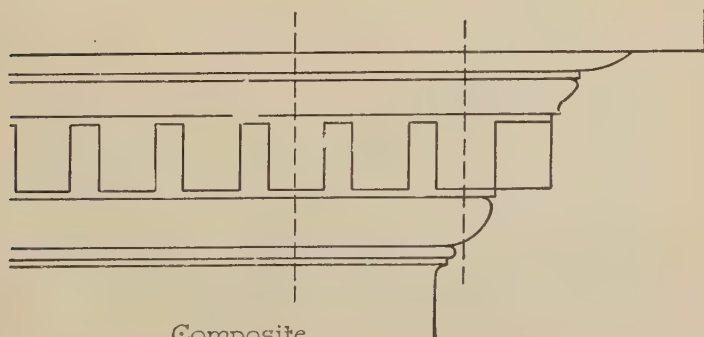
Ionic

(b)



Corinthian

(c)



Composite

(d)

FIG. 42

3. The projection of the fillet, in the bed mold of the mutulary Doric.

4. Twice the projection of the triglyph, which is seen in profile.

5. Half the projection of the Tuscan bed mold, of the Tuscan and Doric abacus, and of the Doric mutule band.

It also gives the axis of the extreme dentil, or first half of the double dentil, in the denticulated Doric, Ionic, Corinthian, and Composite orders, as shown in Fig. 42, and the position of the eye of the Ionic scroll, which is on a level with the bottom of the echinus, as in Fig. 41.

DRAWING

80. General Proportions.—Since the relative size of all the parts in Vignola's orders is fixed, any of them can be drawn out in accordance with these rules, if a single dimension is determined. The width of a dentil or the length of a modillion suffices to determine everything else. But the data generally given are either the lower diameter of a column, the height of a column, or the whole height of the order, with or without a pedestal.

81. If the lower diameter is given, the procedure is as follows: Divide the diameter in two, draw the axis of it, and then divide each half into three equal parts, as shown in Fig. 49 (*a*); this gives the scale of sixths. Divide in two the two outer sixths; this gives the upper diameter of the shaft, which is five-sixths. Lay off on the axis the height of the column—by diameters, 7, 8, 9, or 10, according to the order—and of the entablature, which is one-fourth the height of the column. Mark the height of the base, half a diameter, or three-sixths, and then that of the capital, two-, three-, or seven-sixths.

Then divide the total height of the entablature into seven, eight, eighteen, or ten equal parts, according as it is Tuscan, Doric, Ionic, or Corinthian, or use halves, quarters, or eighths of a diameter, and mark the heights of the archi-

trave, frieze, and cornice, drawing horizontal lines through the points of division. [Fig. 43 (*a*) illustrates this procedure for the Tuscan order.] Then carry up, vertically, the outer lines of both the upper and the lower diameters of the shaft, drawing from the point where the line of the upper diameter cuts the lower edge of the cornice a line at 45° , to determine the projection of the cymatium or that of the mutule or of the corona.

Add one-third of the height of the column for the pedestal. Divide this into nine equal parts, taking the upper ninth for the cap, and the lower two-ninths for the base. Vignola makes the base of the pedestal only one-ninth of the height of the pedestal instead of two-ninths as here determined.

82. If the height of the column is given, a fourth part of this added at the top gives the height of the entablature, and a third part added below gives the height of the pedestal, as shown in Fig. 43 (*a*). One-seventh, one-eighth, one-ninth, or one-tenth of the height of the column gives the lower diameter of the shaft. The drawing may then be carried forwards as just stated.

83. If the total height of the order is given, without the pedestal, a division into five equal parts gives four parts for the column and one for the entablature, as in Fig. 43 (*a*).

If there is a pedestal, and it is of the regular height of one-third the height of the column, the division of the total height must be into nineteen equal parts, four of which go to the pedestal, twelve to the column, and three to the entablature, as in Fig. 43 (*b*).

The lower diameter can then be obtained from the height of the column, and the drawing completed, as before.

NOTE.—The division of a given dimension into equal parts may be effected with the dividers, or, more easily, by using a scale of equal parts that are the same in number as the desired subdivisions, but a little larger, and holding this scale obliquely between the extreme limits of the space to be divided, as shown in Fig. 43. The division of vertical dimensions into five, seven, eight, nine, ten, eighteen, or nineteen equal parts, as here required, is thus easily accomplished. To insure accuracy, the lines marking these divisions should be horizontal, not at right angles to the direction of the scale.

84. Cornices.—The Tuscan cornice may be drawn by dividing its height into quarters, as is done in Fig. 44, giving the upper quarter to the ovolo and the lower to the bed mold, and the middle half to corona, bead, and fillet. A 45° line gives the projection of the bed mold, ovolo, and the cornice itself.

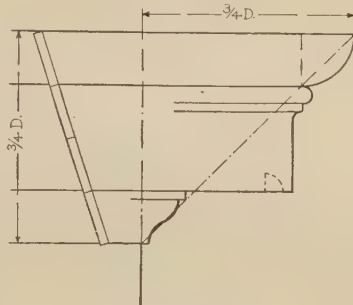


FIG. 44

The Doric cornice is also divided into four equal parts, the upper one comprising the cymatium and fillet, the next the corona and the small cyma reversa above it, the third the mutules (or the dentils with the mutules above them), and the lower one the bed mold, including the cap of the triglyph, which is narrower in the mutulary Doric than in the denticulated by the width of the fillet above it, as shown in Fig. 45.

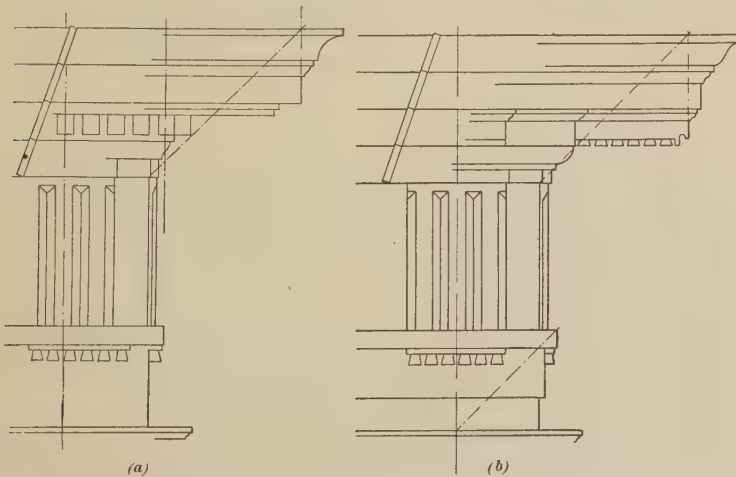


FIG. 45

A 45° line drawn outwards from the middle of the top of the abacus gives, where it cuts the lower line of the frieze, the projection of the tænia. A similar line, where it cuts

the upper line of the frieze, gives the axis of the next triglyph, as in Fig. 37. The triglyphs, with their cap, are drawn next, and the regula and guttæ, then the mutules, or the dentils.

85. In the Doric order, a line of 45° drawn from the bottom of the cornice gives the face of the corona in the denticulated Doric, the face of the mutule in the mutulary; in the other orders, a similar line gives the projection of the cymatium, as in Fig. 45.

In putting in dentils, draw first the one over the axis of the column, then the double dentil, the first half of which is centered over the lower face of the column, and then the intermediate ones, three, two, or one, according as the order is Doric, Ionic, Corinthian, or Composite, as in Fig. 42. The

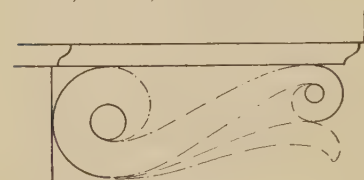


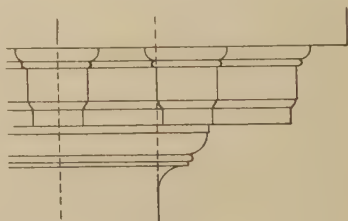
FIG. 46

interdentil is half the width of the dentil except in the Composite.

One Corinthian modillion comes over the axis of the corner column and one over the outer face of the double

dentil, as in Fig. 42 (c). In drawing the side of a modillion, put in first, at the outer end, a semicircle half its height and one at the inner end nearly the whole height; then the rosettes, one twice as large as the other; then the connecting curves; and finally the leaf beneath, as shown in Fig. 46.

In Palladio's Composite cornice, one block is set over the axis of the column, and the double block at the corner has its inner face on a line with the face of the frieze below. The blocks are about half a diameter on centers, the interblock being one-twenty-fourth of a diameter wider than the block itself, as shown in Fig. 47.



Composite

FIG. 47

86. Architraves.—The Tuscan architrave has only one fascia, or band, as shown in Fig. 48 (a); the Composite two,

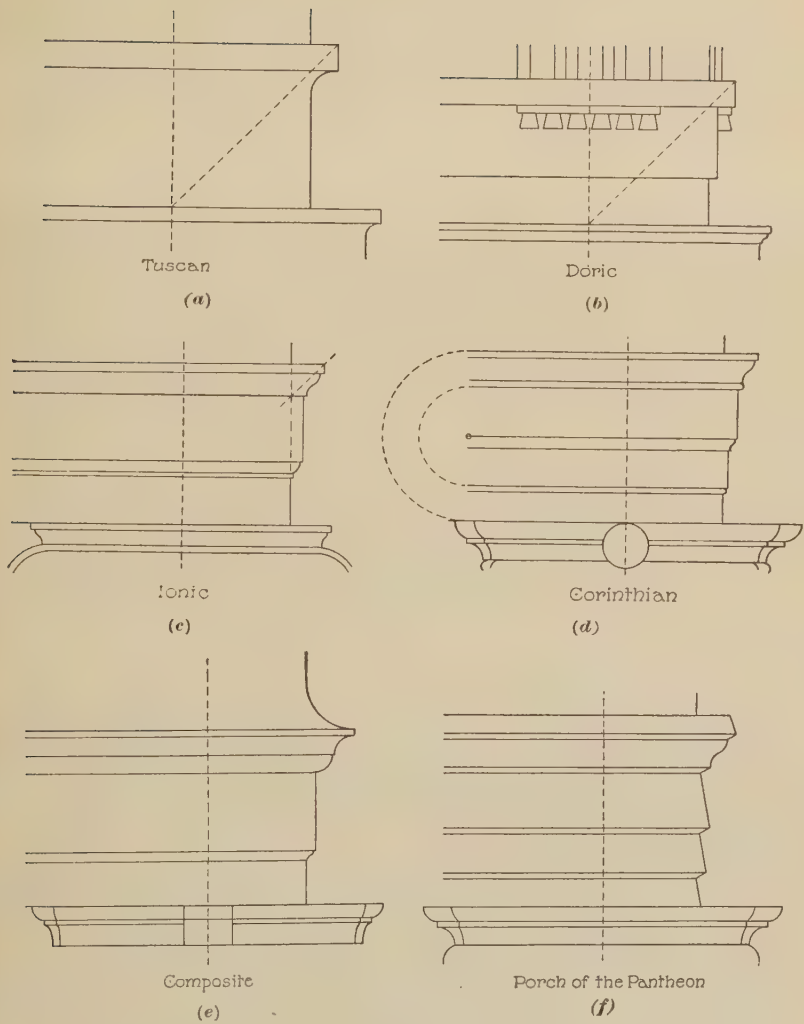


FIG. 48

as in (*c*); and the Corinthian three, as in (*d*). The Doric has sometimes one, but generally two, as shown in (*b*), and the Ionic has generally two, as in (*c*), but sometimes three. The lower band is always the narrowest and is set on a line with the face of the shaft below and that of the frieze above.

All the architraves have a cymatium, or crowning member, which in the Tuscan and Doric is a broad fillet, called the *tænia*, and in the Ionic and Corinthian is a large cyma reversa, surmounted by a fillet and generally supported by a bead. The lower bands often have, as a cymatium, a small cyma reversa, bead, or ovolo, and all three bands are sometimes sloped backwards, as in the entablature of the porch of the Pantheon in Rome, Fig. 48 (*f*), so as to diminish the projection of the crowning moldings, which generally have a projection beyond the face of the frieze equal to their height.

87. The Tuscan *tænia* has beneath it the characteristic Tuscan *congé*, as shown in Fig. 48 (*a*). Beneath the Doric *tænia*, and directly under each triglyph, in (*b*), is a narrow fillet, which sometimes has a beveled face, called the *regula*, beneath which are the six *guttæ*. These are sometimes truncated cones, as in the Greek order, and sometimes truncated pyramids. The *guttæ*, which almost touch at the bottom, are twice as high as the *regula*. Both together are just as high as the *tænia*, or one-twelfth diameter, so that the three are one-sixth of a diameter high. They accordingly occupy the upper third of the height of the architrave, which is three-sixths high, the lower band occupying the lower third.

The two lower bands of the Corinthian architrave occupy half its height, and the lower band with its cymatium is just as wide as the moldings that crown the upper band. The second band with its cymatium is just as wide as the third band without, as shown in Fig. 48-*(d)*.

88. Capitals and Bases.—In drawing capitals, it is best to put in first the axis of the column and the vertical faces of the shaft, then the horizontal lines, and lastly the profile, beginning at the top. But in drawing bases, it is

best to put in the profile of the molding before the horizontal lines.

The Tuscan base, Fig. 49 (*a*), is half a diameter high, half of which goes to the plinth and half to the base molding, which is made to include the cincture, or broad fillet at the bottom of the shaft, which in the other orders is not counted as part of the base. But this is merely saying that the Tuscan base is not quite half a diameter high.

All the other bases, including the Attic base, are just half a diameter high. All the plinths are eight-sixths wide and one-sixth high, except the Tuscan and Doric, which are one-quarter of a diameter high. It is not worth while to define the proportions of the other bases.

89. The Tuscan capital, Fig. 49 (*a*), is half a diameter high, or three-sixths, the upper sixth comprising the abacus with its fillet, the middle sixth the echinus and the fillet below it, and the lower sixth the necking. The upper fillet is a quarter of a sixth wide, the lower one a sixth of a sixth. The abacus

is seven-sixths wide; that is, it projects one-sixth on each side beyond the upper diameter of the shaft.

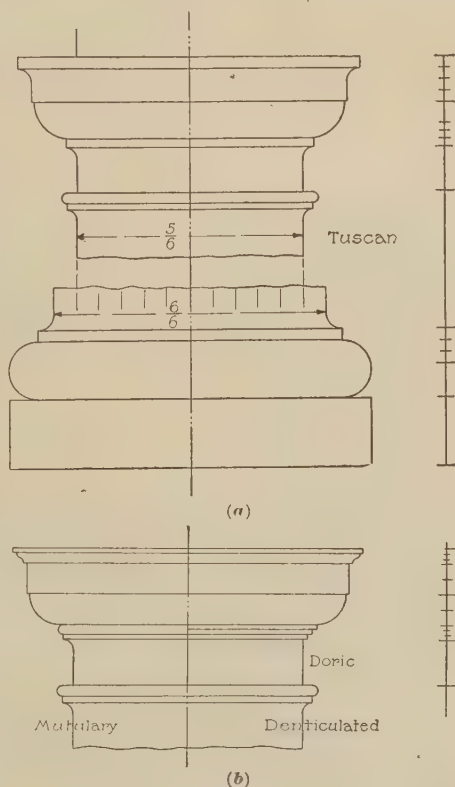


FIG. 49

90. The Doric capital, Fig. 49 (*b*), is also three-sixths of a diameter high, the two upper sixths being divided into thirds, and these again into thirds, to give the height of the smaller moldings. The denticulated capital generally has three fillets, the mutulary, and a bead and fillet.

The astragal, which in the other capitals is one-twelfth of a diameter high, is in the Tuscan and Doric orders one-fourth smaller, or one-sixteenth of a diameter, the bead being one-twenty-fourth of a diameter high. In drawing the astragals, draw first the horizontal line at the top, which occupies two-thirds of the projection, otherwise the congé below is likely to be slighted. The bead and congé should have their full measure of 180° and 90° , as shown in Fig. 50.

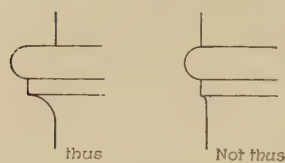


FIG. 50

91. The Ionic capital, which is one-third of a diameter in height, or four-twelfths, is also divided into three parts, but unequally. The abacus occupies the upper quarter, or one-twelfth, and had better be put in first. The echinus occupies rather more than half of the remaining space, namely, five-ninths. In the Composite capital, the abacus occupies the upper sixth and a little more, and the echinus and the astragal the next one, as shown in Fig. 35.

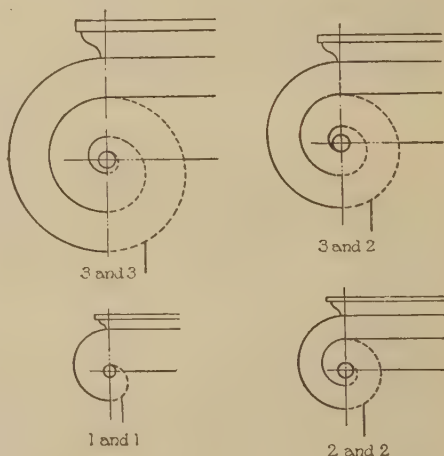


FIG. 51

The eyes of the Ionic scroll are in line with the top of the astragal and with the lower diameter of the column, and should be put in first, as in Fig. 51. The scrollis make three

complete turns and finally are tangent to the upper side of the eye. They can best be drawn by putting in first three semicircles on the outer side, and then three smaller ones on the inner side. In working on a small scale, two semicircles on each side will suffice, or three on the outer side and two on the inner, as in the plates. But one is never enough. The eyes of the Composite and of the Roman Ionic capitals are set nearer together, as shown in Fig. 35.

92. In drawing a Corinthian capital, Fig. 52 (a), it is best to put in first the astragal and the lower line of the architrave, carrying up on each side the outer lines of the shaft; then the abacus, fleuron, and scrolls. The double scroll at the

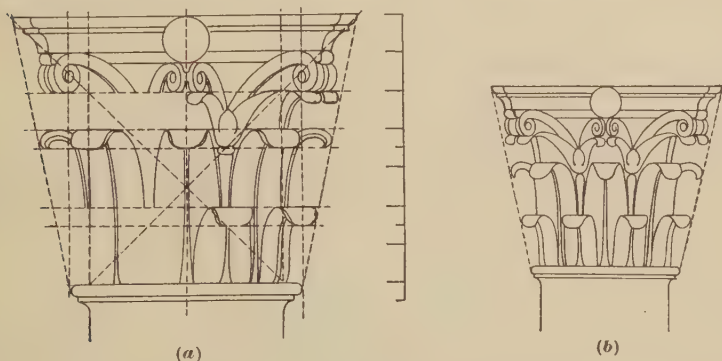


FIG. 52

corner falls just outside of these vertical lines. It appears slightly elliptical in shape, not circular, and the outer scroll is more elliptical than the inner, being more foreshortened. The small scrolls under the fleuron are also foreshortened into ellipses; then the five leaves of the second row, the middle one in elevation, the two side ones in profile, and the other two at 45°, carrying down the mid-ribs to the astragal. Their tips turn down half a sixth, those of the corner leaves coming just on the outer lines of the upper shaft. Of the four leaves of the lower row, the two inner ones occupy the spaces between these mid-ribs, and the ends that turn over fall entirely within the outline of the lower parts. The two

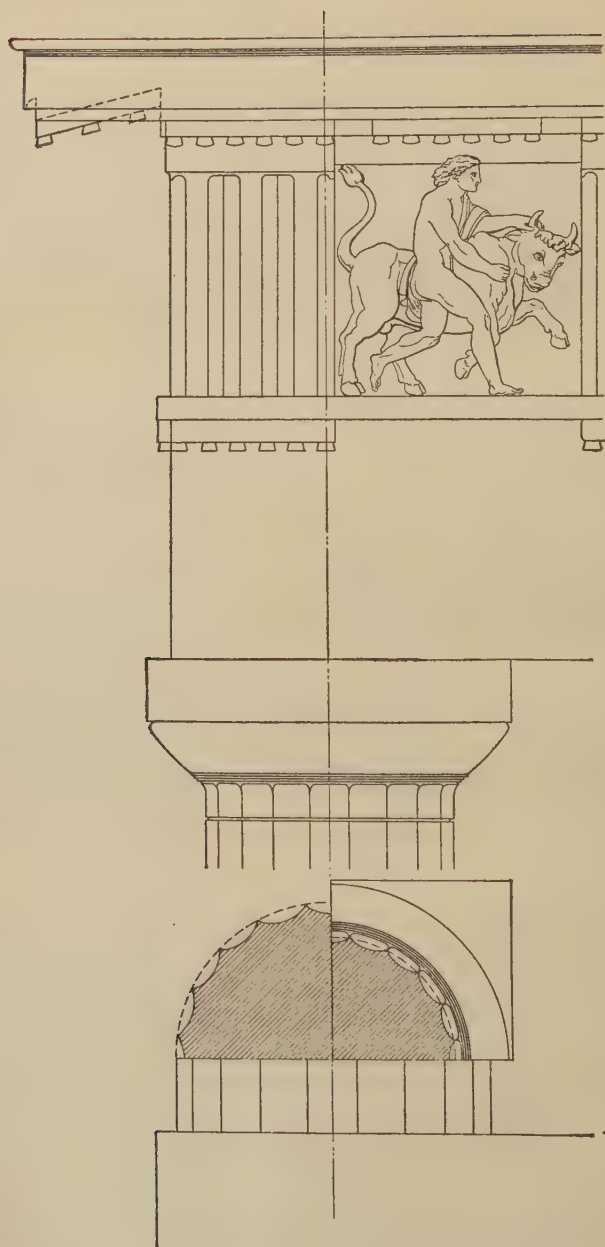
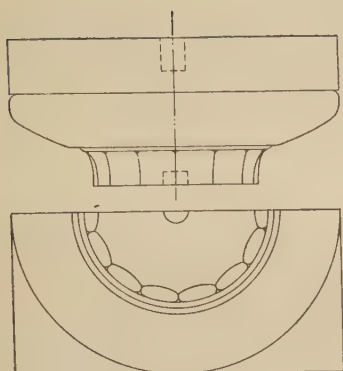
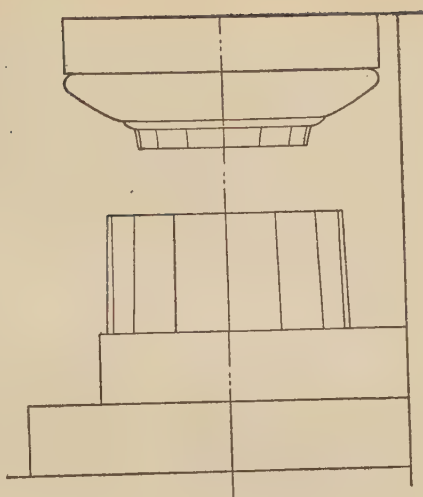


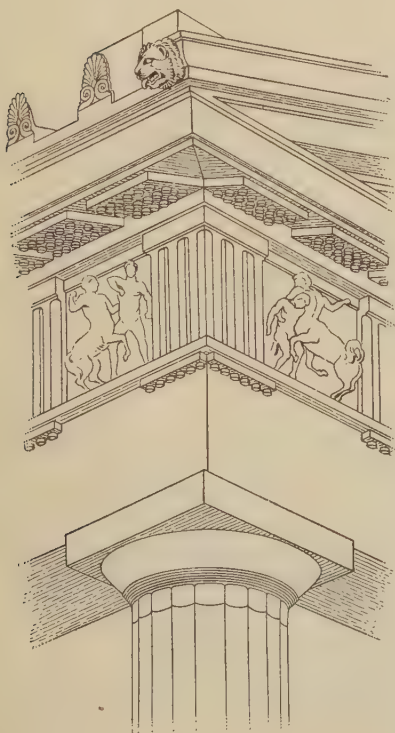
FIG. 53



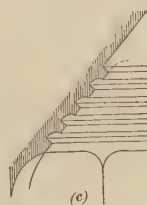
14 Channels
Columns from Argos
(a)



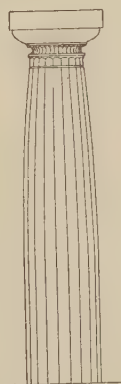
Temple at Assos
(b)



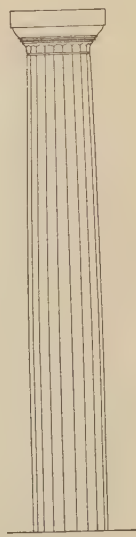
(d)



(c)



Paestum



Propylaea

(e)

outer leaves extend on either side slightly beyond the width of the shaft below, and their tips fall just outside the lower lines of the leaves, being about six-sixths of a diameter apart. They accordingly come just over the outer lines of the lower diameter, just as the tips of the corner leaves above them come on the lines of the upper diameter.

A line drawn tangent to the astragal and to the abacus is also very nearly tangent in all three rows of leaves. The caulicoli, the buttons, the third row of leaves, and the lower parts of the volutes follow, in this order.

The smaller the scale of the drawing, the more straight and upright should the acanthus leaves be made, as shown in Fig. 52 (*b*).

THE GREEK ORDERS

93. Although the different examples of the Greek Doric and Ionic orders differ considerably among themselves, both in the proportions of the columns and in the treatment of details, the proportions of the entablature are tolerably uniform and are, in general, the same for both orders, the architrave and frieze being both about three-quarters of a diameter in height and the cornice about half a diameter, as shown in Fig. 53. The entablatures, as has been said, are about two diameters high, no matter how tall or how short the columns may be. Their chief characteristic is the height of the architrave and the shallowness of the cornice. The diminution and the entasis of the columns begin at the bottom of the shaft.

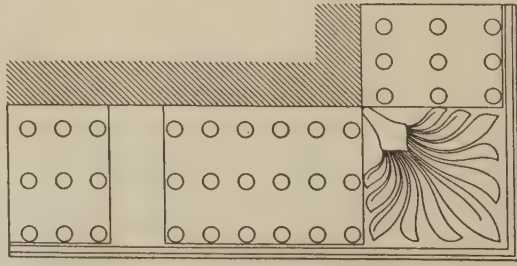
GREEK DORIC—PLATE XIII

94. The Greek Doric, Plate XIII, has no base, the shaft standing on three large steps, the upper one of which is called the *stylobate*, Fig. 53. It usually has twenty channels, which are generally elliptical in section, but some small columns have only sixteen, or even fourteen, as at Argos, Fig. 54 (*a*). In a number of examples, an arris instead of a channel comes on the axis of the column, as is seen both at Argos and at Assos, Fig. 54 (*b*). Instead of an astragal,

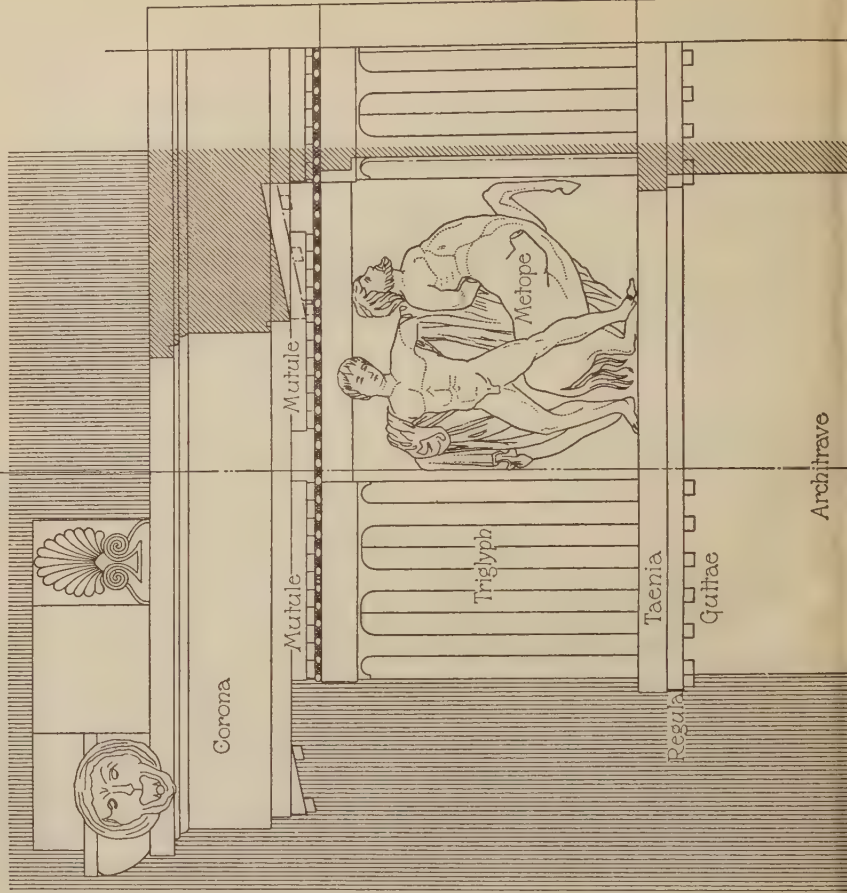
THE GREEK ORDERS

DORIC ORDER FROM THE PARTHENON

Gymnasion



PLAN OF MUTULES



Corona

Mutule

Mutule

Triglyph

Metope

Taenia

Regula

Quirac

Architrave

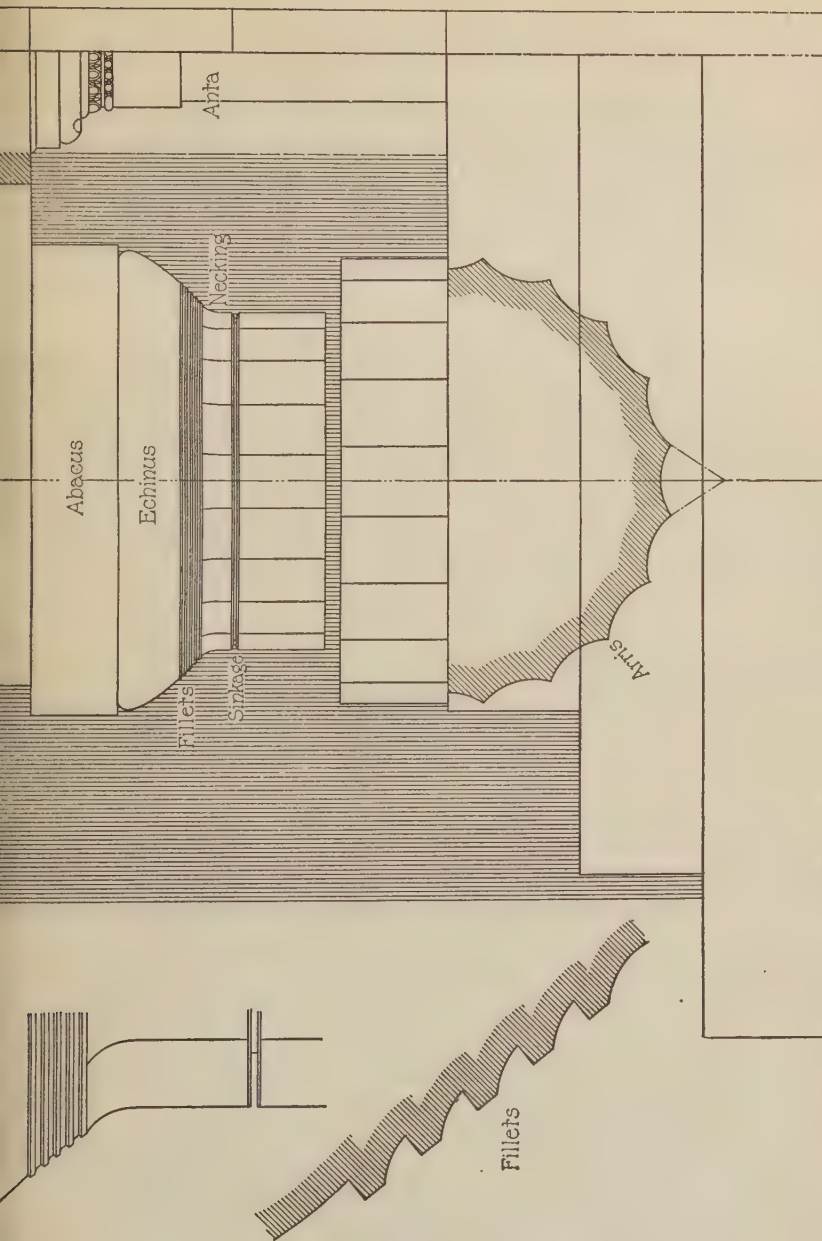


PLATE XIII

a groove, or *sinkage*, separates the shaft from the necking of the capital, and the channels are carried past it quite up to the fillets at the base of the echinus, as shown in Fig. 53. These fillets vary in number. They are not vertical on the face, but follow and continue the slope of the echinus, and their upper surfaces are also beveled, as in Fig. 54 (*c*). The echinus itself has an elliptical or hyperbolic profile, the earlier examples being the most convex and the later ones hardly differing from a straight line. The abacus has no moldings.

95. The architrave also is plain, and is crowned by a *tænia*, below which is a broad *regula* and six short *guttæ*. In the earlier examples, the face of the architrave is set just over and in line with the upper diameter of the shaft, but in the later ones, it overhangs, coming over the lower diameter, and the echinus is made steeper, as well as straighter, as has been said, as if to support it.

The triglyphs in the frieze are shorter and broader than in the Roman Doric, and are set flush with the architrave below, the metopes being set back. They are also thicker than the Roman triglyphs, and the channels are deeper, those at the edges cutting back at an angle of 45° , the others generally at 60° , and they run nearly up to the broad fillet, or band, that constitutes the cap of the triglyph. This is only as wide as the triglyph itself, not breaking round the corners, and it is not continued between the triglyphs, the cap of the metopes being narrower.

As in Vignola's denticulated Doric, the mutules on the soffit of the corona slope up, and have only eighteen *guttæ*, and they occur over the metopes as well as over the triglyphs, as shown in Fig. 54 (*d*). The mutules are thicker than those in the denticulated Doric, though not so thick as in the mutulary. The cymatium generally consists of an elliptical ovolo and a fillet, the soffit of which is beveled. But different examples vary in almost every one of these particulars.

At the corner of a building the triglyphs are set, not over the axis of the column, but at the extreme end of the frieze, two coming together and making a solid block. As the

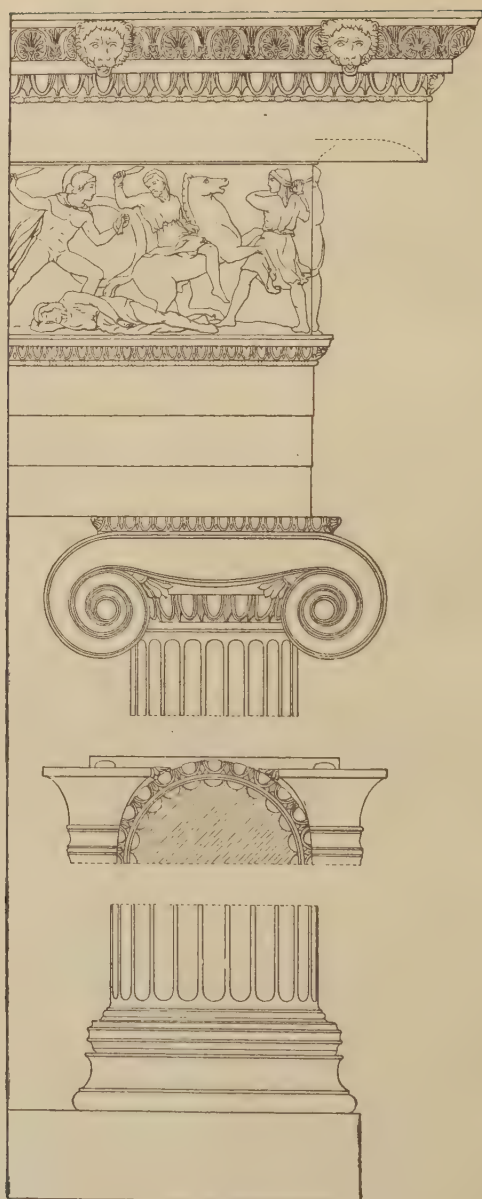
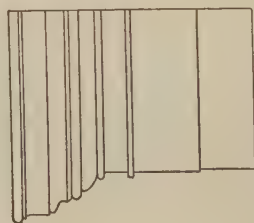
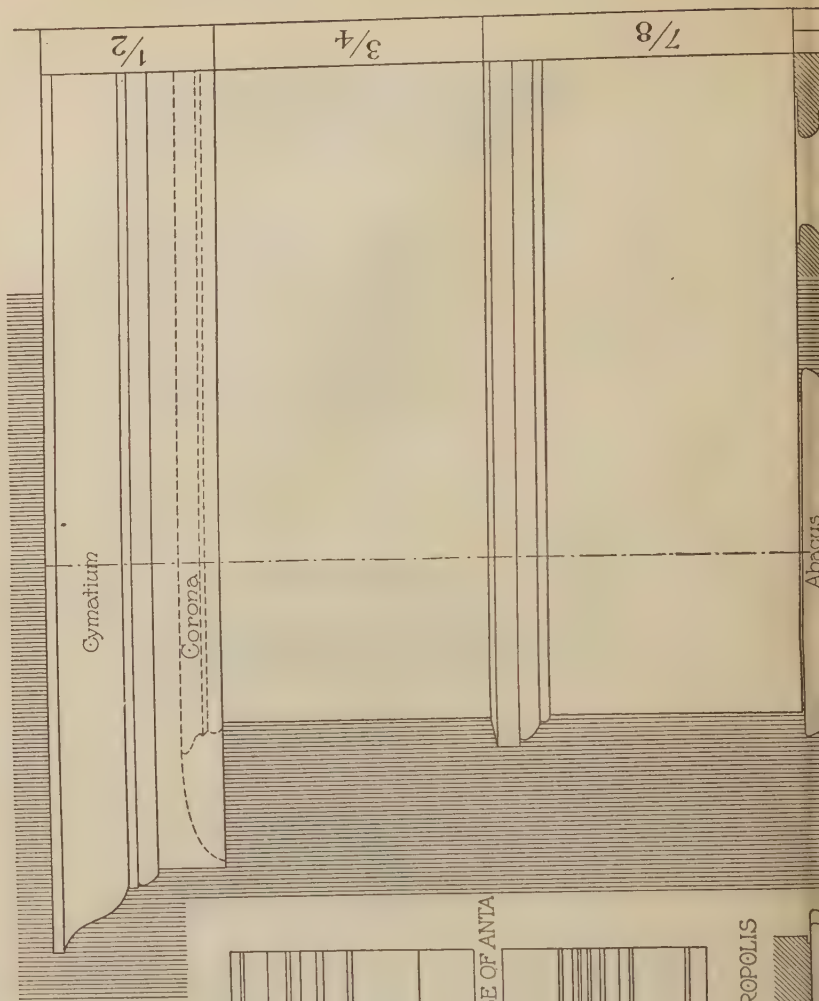


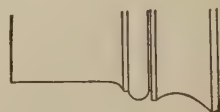
FIG. 55

THE GREEK ORDERS

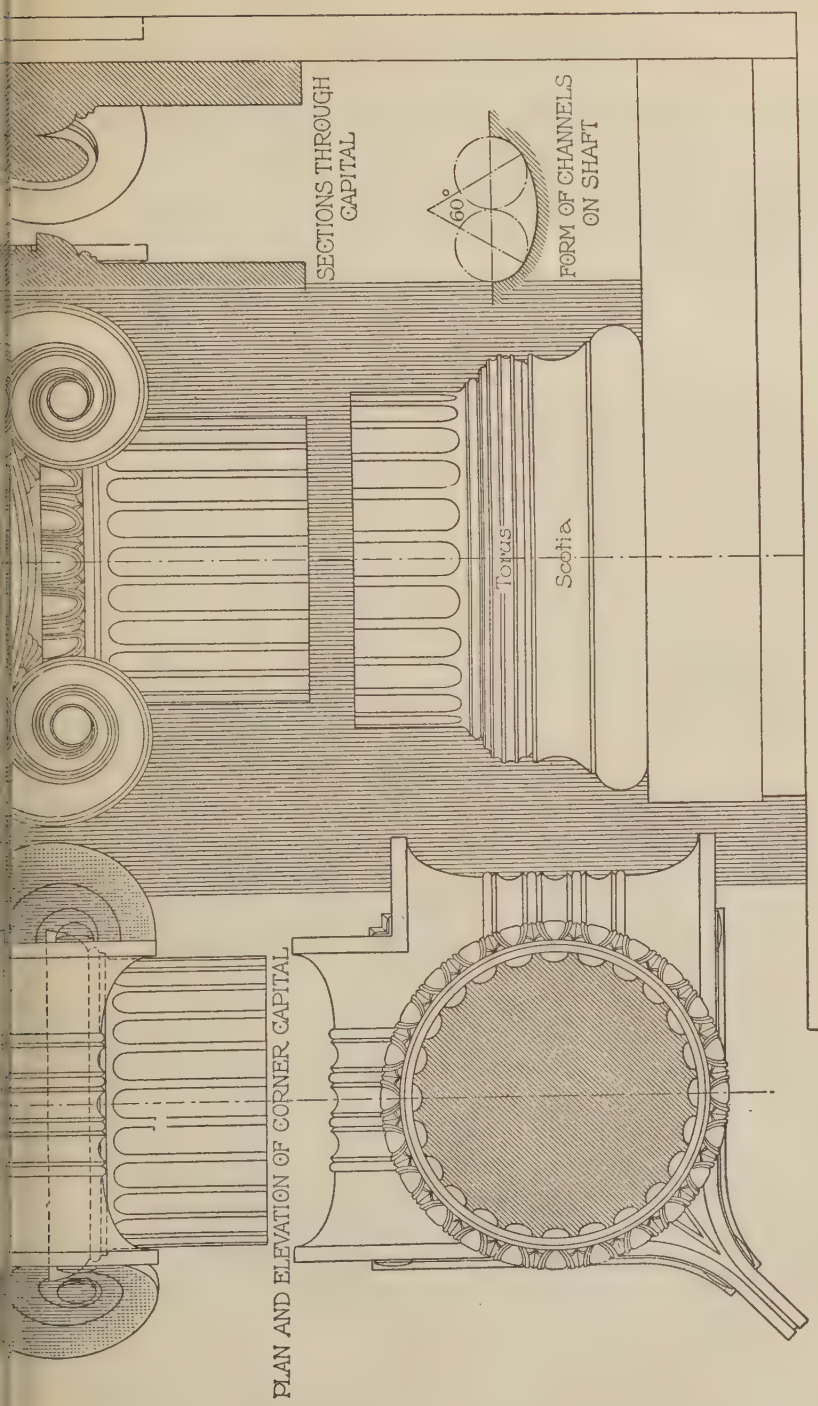
IONIC ORDER FROM THE TEMPLE ON THE ILLISSUS



CAPITAL AND BASE OF ANTA



IONIC BASE.
FROM THE CHORAGIC COLUMN ON THE ACROPOLIS



PLAN AND ELEVATION OF CORNER CAPITAL

SECTIONS THROUGH CAPITAL

FORM OF CHANNELS ON SHAFT

Torus

Scotia

metopes do not vary in size, being nearly square, this brings the three corner columns nearer together than the others.

96. In the best Greek examples, all the columns slope in a little, so that the corner column, which is a little bigger than the others, has its inner face nearly vertical. The horizontal lines curve slightly, being convex up, the vertical faces incline a little, either out or in, and the moldings are, as has been stated, generally elliptical or hyperbolic in section, rather than arcs of circles.

The columns vary in height from about five to eight diameters, the earlier ones being the shortest. The entasis, or curvature in the outline of the shaft, and the diminution in the width of the shaft, from bottom to top, which sometimes amounts to one-third of the diameter, are also much more pronounced in the earlier examples than in the later ones, as shown in Fig. 54 (*e*). This seems to show that the original of the Doric column was not a wooden post, as has been thought, nor a pile of masonry, but probably a piece of rubblework covered with stucco, like the rubble walls.

GREEK IONIC—PLATE XIV

97. The general proportions of the Greek Ionic entablature, Plate XIV, are, as has been stated, about the same as in the Doric, but the columns are more slender, varying from about seven diameters in height to more than ten, and the architrave, frieze, and cornice are often made very nearly equal in height, as shown in Fig. 55.

The base is like the Attic base, except that the scotia is larger, constituting the principal feature, that the upper torus is larger than the lower one, that the fillet above the scotia projects as far as the face of this torus, and that there is no plinth. As the base is still half a diameter high, the upper torus and scotia are very much larger than in the Roman Attic base. The lower torus is sometimes very small indeed, and is occasionally omitted altogether, as in one of the Choric columns on the south side of the Acropolis at Athens, Fig. 30 (*f*).

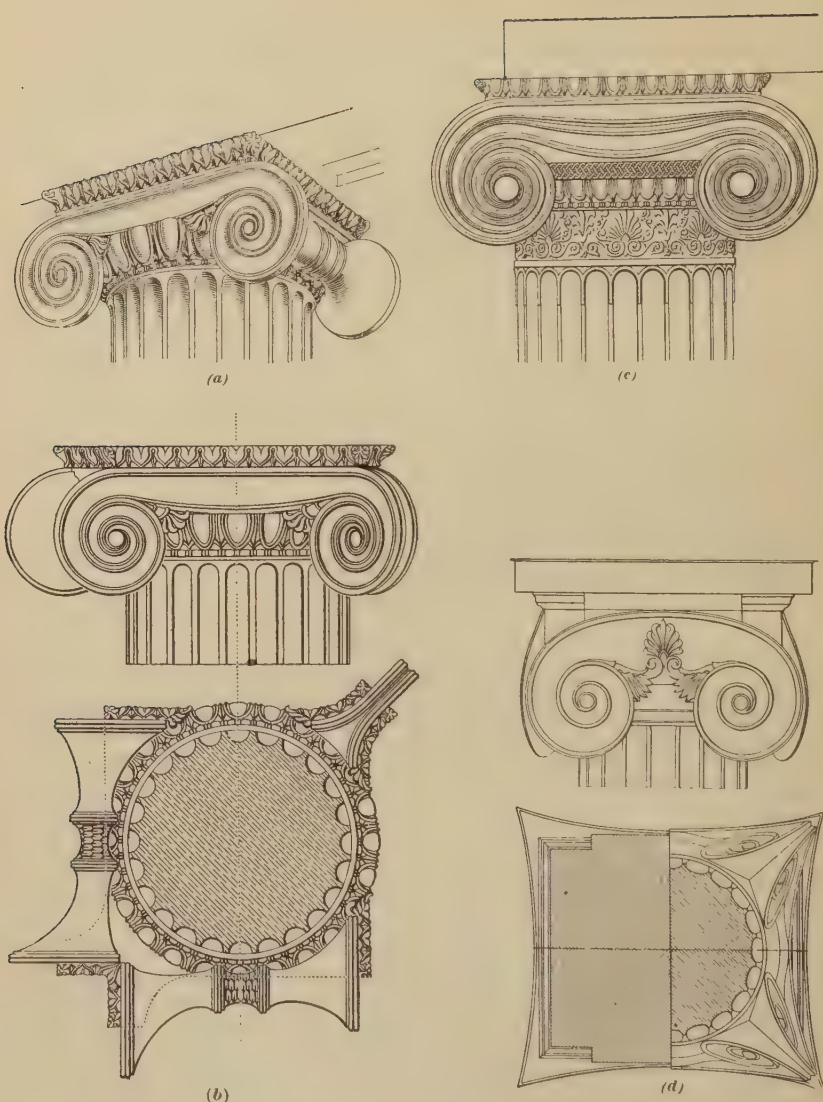


FIG. 56

98. The shaft is fluted just as in the Roman Ionic, having twenty-four channels, and the capital resembles, in general, Vignola's capital with balusters. But the scrolls are much larger, measuring a full diameter and a half from side to side, and two-thirds of a diameter from the architrave to the bottom of the curve. The capital, measured from the

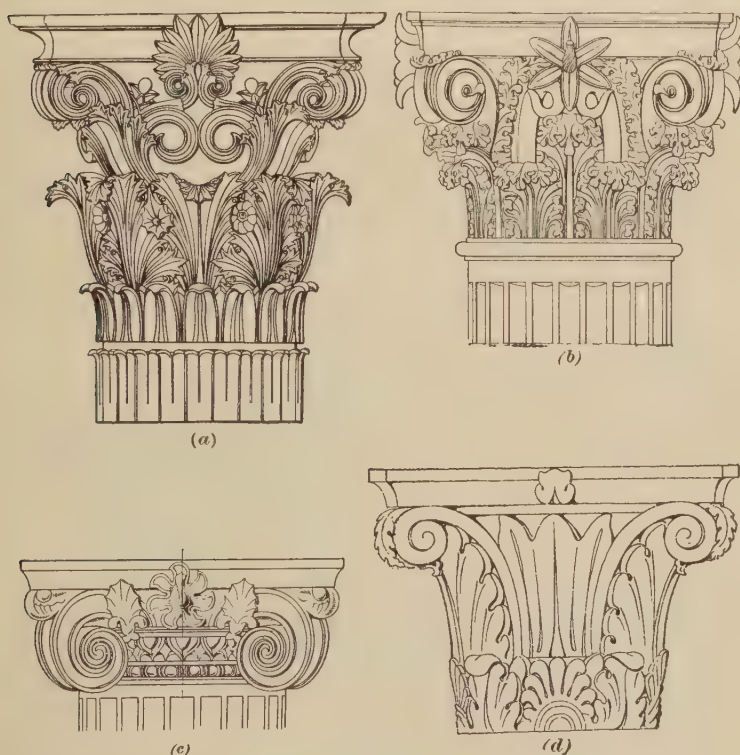
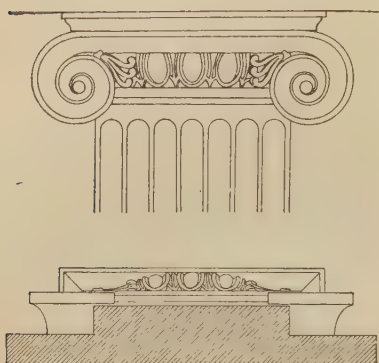
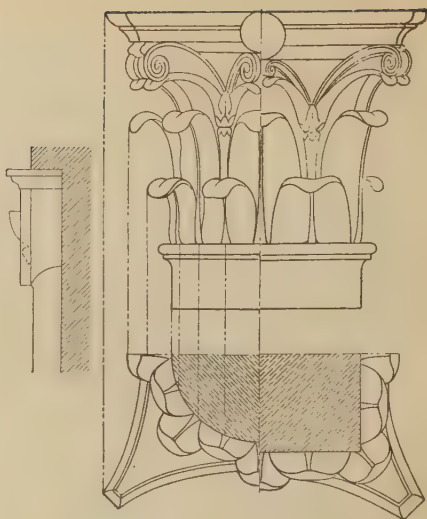


FIG. 57

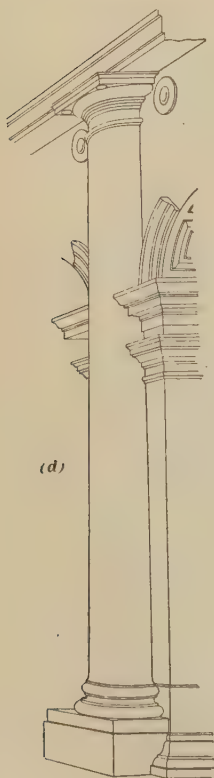
architrave down to the astragal, is half a diameter high, instead of a third; the abacus is very small, consisting generally of a single ovolo; and the *cushion* between the abacus and the echinus is very wide, its lower outline being curved downwards, as shown in Fig. 56 (a). The sprigs of honeysuckle, accordingly, do not cover the eggs and darts, five of which are visible between the scrolls, instead of three.



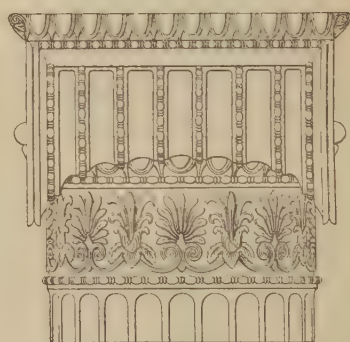
(a)



(b)

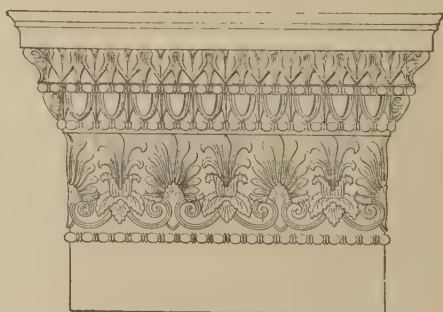


(d)



Column

(c)



Pilaster

(e)

From the Farnese Palace

99. The architrave is sometimes plain, and sometimes divided into two or three bands. The frieze, or zoöphorus, is wide, and the bed mold that crowns it is often counter-sunk into the soffit of the corona, so that it does not show in elevation, as in Fig. 55. It is noticeable that though dentils are, historically, a distinctively Ionic feature, they are omitted in many Greek examples. The cymatium is a large cyma recta, and has a fillet and bead below it, which is sometimes undercut, so as to make a little beak molding.

But here, as in the Greek Doric, there is a great variety in the details of different buildings. The four faces of the capital are sometimes made alike, with double scrolls on each corner, as in the Roman Ionic, and these scrolls are sometimes connected under the abacus by a continuous curve, convex up, instead of by a horizontal line, as shown in Fig. 56 (*d*). Sometimes a corner column shows scrolls on the two outer faces and balusters on the two inner ones, the double scroll on the corner projecting at 45°, as in Fig. 56 (*b*). Some examples have a wide necking, adorned with the honeysuckle ornament, below the echinus, as shown in Fig. 56 (*c*).

100. A few Corinthian capitals are to be found in Greece, but the buildings in which they occur are in other respects Ionic, or even Doric [see Fig. 57 (*a*)].

In the later Greek colonies in Southern Italy are found interesting varieties of all the orders.

The Corinthian capitals receive a local development quite unlike that which was finally adopted in Rome itself, as at Tivoli, Fig. 57 (*b*) and (*c*), Pompeii, and Herculaneum Fig. 57 (*d*). Since the revival of Greek architecture, other variations have appeared in France, Germany, and Italy.

PILASTERS—PLATE XV

101. The Romans made their pilaster capitals resemble those of the columns. This works well, except with the Ionic capital, in which the projecting echinus presents an almost insuperable difficulty, as is evident in Fig. 58 (*a*).

As **pilasters** do not generally diminish in width at the top, their capitals are one-fifth broader than those of the columns. But pilasters are often made half a sixth narrower than the columns at the bottom, and half a sixth wider at the top, having thus a uniform diameter of five-sixths and a half. In the Corinthian pilaster capital, the extra space is taken up by making the leaves a little broader, and setting them farther apart, as shown in Fig. 58 (*b*).

Pilasters generally project from the wall a quarter of their diameter, but sometimes they have to be made thicker in order to receive string-courses or other horizontal moldings that they cut across. If made much thicker than this, they are likely to look thicker than the columns alongside of them, and piers always do, noticeably enhancing the slenderness of the columns near them.

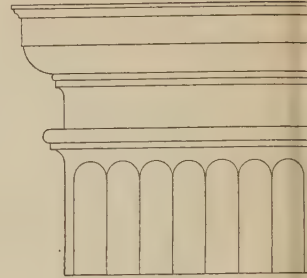
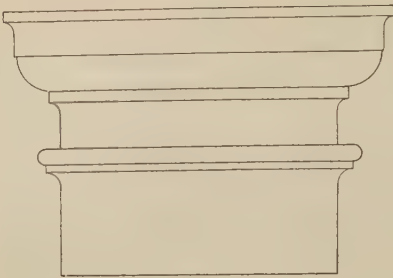
The Greeks gave their pilasters bases like those of the columns, but capitals of their own, composed of a series of moldings, as shown in Fig. 58 (*c*), which is a Greek pilaster capital differing from the column capital in (*d*), but similar in some details.

Pilasters are preferable to half columns, which always look smaller than they are, and have a weak appearance. Moreover, any moldings that they interrupt seem to cut them in two, as shown in Fig. 58 (*d*). In these respects, three-quarter columns are better, though they are likely to look clumsy, and they inevitably make an awkward junction with the wall behind them. They also make it uncertain which is the principal supporting member, the wall or the column.

PEDESTALS, ETC.—PLATE XV

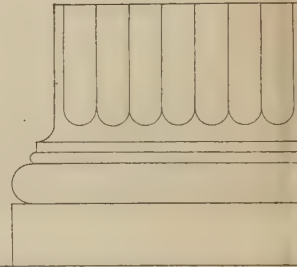
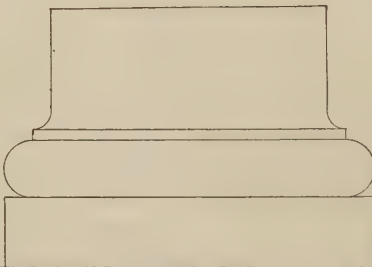
102. As has already been said, a short pier is called a post, and, if it supports something, a **pedestal**. The pedestals that support columns are generally made one-third the height of the column. The cap is one-ninth the height of the pedestal, and generally consists of a bed mold and corona. There is no cymatium, a gutter being obviously out of place, but the corona is crowned by a fillet and small

PEDESTALS A



P I L A

DRAWN WITH WID
THE

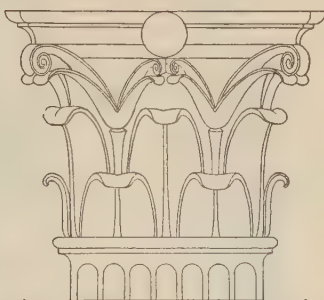


TUSCAN

DORIC

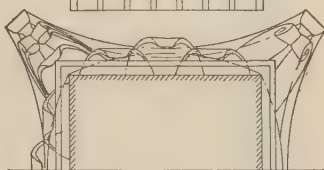
ACCORDING TO VIGNOLA THE PEDESTAL IS ONE-TH
PEDESTALS DRAWN ACCORDING TO SIR WM. CHAMBER

PILASTERS

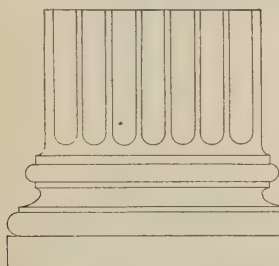


ERS

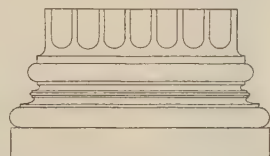
UPPER DIAMETER, EQUAL
R DIAMETER



PLAN OF CORINTHIAN PILASTER CAPITAL
DOTTED LINE SHOWS LIP OF BELL



ATTIC
BASE

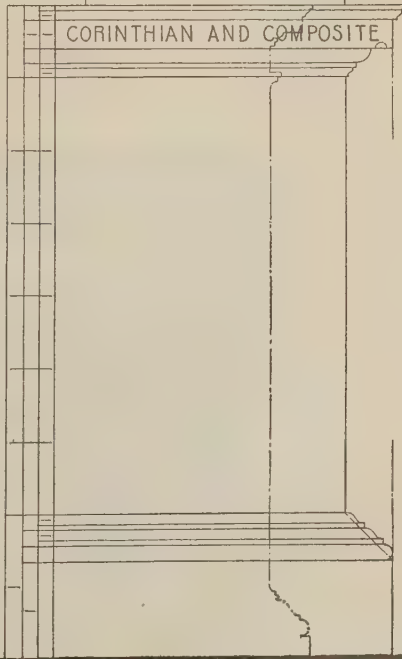
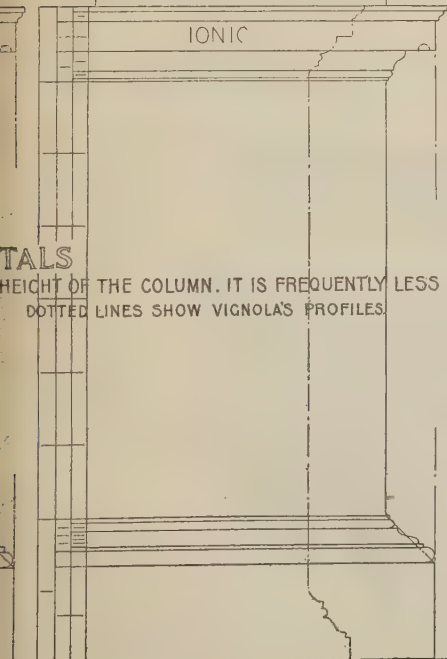


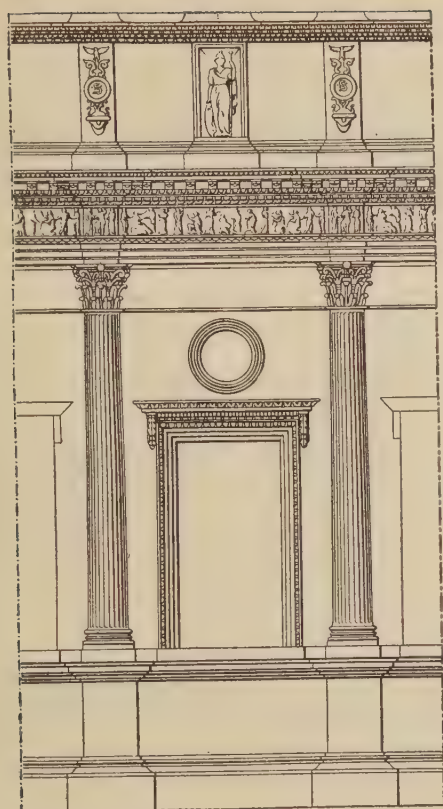
IONIC

CORINTHIAN AND COMPOSITE

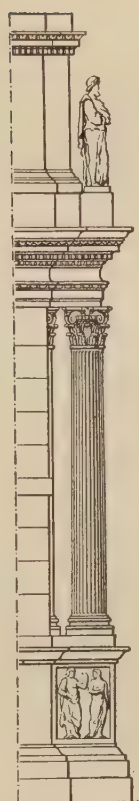
TALS

HEIGHT OF THE COLUMN. IT IS FREQUENTLY LESS
DOTTED LINES SHOW VIGNOLA'S PROFILES

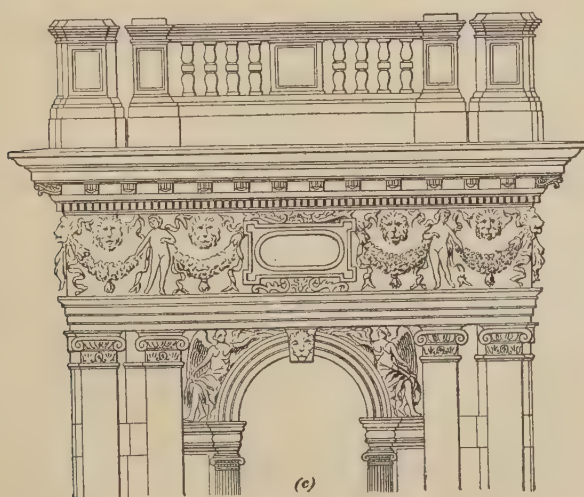




(a)



(b)



(c)

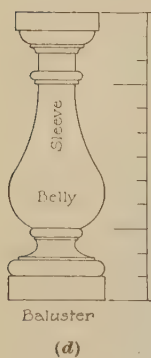
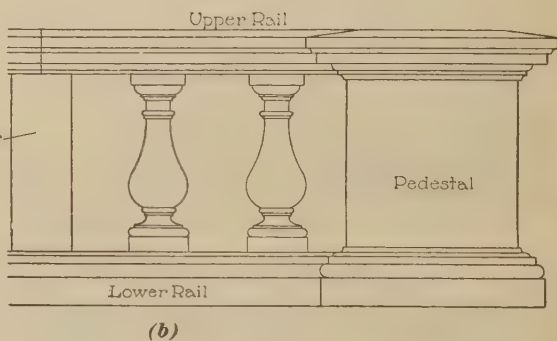
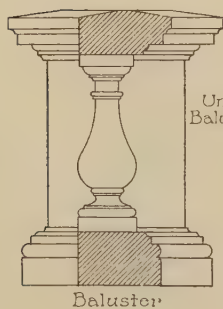
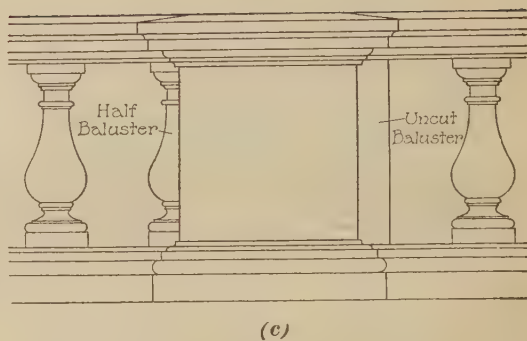
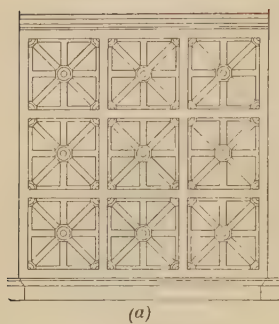


FIG. 60

cyma reversa. The base, which is two-ninths of the height of the pedestal, or, according to Vignola, only one-ninth, like the cap, consists of a plinth and several combination base moldings, among which a cyma recta with a torus below it is generally conspicuous.

103. The moldings, in both cap and base, are fewer and consequently larger and simpler in the Tuscan and Doric orders than in the Ionic and Corinthian, the Tuscan, according to Vignola, having no corona, and the Corinthian a necking and astragal. The cap projects less than its own height, in many examples, and the plinth just as much as the corona.

But pedestals vary greatly both in their proportions and in their moldings.

104. Parapets.—A wall low enough to lean on is called a **parapet**, and whether low or high is often strengthened by occasional posts or pedestals, sometimes of the same height, sometimes higher. In either case, the wall, or parapet, has a cap and base, which may or may not be like those of the pedestals or posts. A similar strip of wall, with the wall continued above the cap, as shown in Fig. 59, is called a *continuous pedestal*. This often occurs between the pedestals that support pilasters.

105. Balustrades.—In antiquity, parapets were often pierced by triangular penetrations, apparently in imitation of wooden fences, as shown in Fig. 60 (*a*). But in modern times the openings in parapets are generally filled with a sort of colonnade of dwarfed columns called **balusters**. These frequently occupy the whole space between one post or pedestal and the next, forming a **balustrade**, as shown in Fig. 60 (*b*). If the distance is great so that the cap has to be made of several lengths of stone, a block called an *uncut baluster* is placed under the joint. Not more than a dozen balusters should occur together without such interruption. Against the pedestal is often set a half baluster, or, which is better, half of an uncut baluster, to support the end of the upper rail, as in Fig. 60 (*b*).

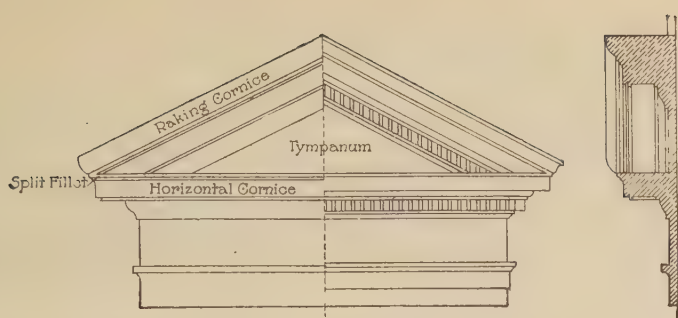
106. The cap and base of the pedestals, or of the parapet or continuous pedestal, are called in a balustrade the *upper* and *lower rails*. The baluster supports the upper rail as a column supports an entablature, and stands on the lower rail as on a stylobate, as in Fig. 60 (*c*). It has its own cap, the height of which, including the astragal, is one-quarter the height of the baluster, and which consists of a plain abacus, echinus, and fillet and necking. These three members are of equal height, as in the Tuscan and Doric capitals.

The base of the baluster is also one-quarter its total height and resembles the Attic base. The scotia, as in the Greek Attic base, is generally made the principal member.

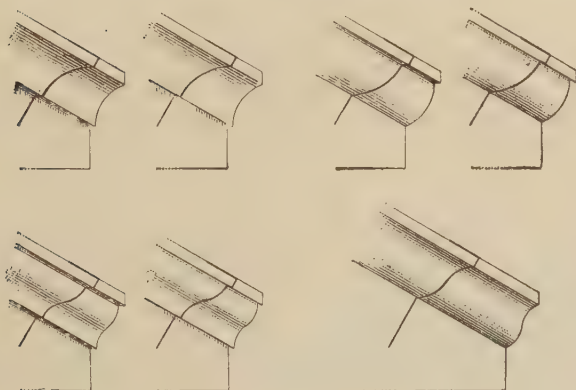
Between the cap and the base is the shaft, or *sleeve*, which has the outline of a quirked cyma reversa, the greatest diameter, or *belly*, coming at about one-fourth of its height, or one-third the height of the baluster, as in Fig. 60 (*d*). Its width at this point is also one-third the height of the baluster, as is also that of the plinth of the base, exactly, and the width of the abacus, almost. The necking is less than half as wide. The point of contrary flexure in the cyma reversa is half way between the cap and the base, or between the upper and lower rails. But these proportions are made somewhat lighter for use with the Ionic and Corinthian orders.

The rails vary in height, being usually from one-sixth to two-sixths of the space between them, like the cap and base of a continuous pedestal; but they are often made much heavier, even one-third or one-half, according to the position of the balustrade.

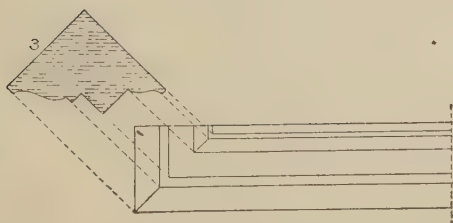
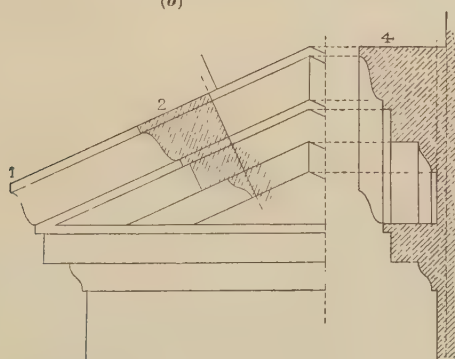
107. Instead of the cyma reversa, a beak molding, as in Fig. 60 (*e*), is often used, and other variations are frequent. Of these, the most important is the so-called *double baluster*, which consists of two small balusters, set together base to base, as in Fig. 60 (*f*). Vignola also used a high block under the plinth. Balusters are often made square in section, like piers, instead of round, like columns. Balusters are set about half their height apart, on centers.



(a)



(b)



(c)

A balustrade, like a parapet, is intended to lean on, and should not be more than about 3 or 4 feet high. While, therefore, columns and entablatures are proportioned to the size of the buildings in which they occur, varying in height from 10 or 12 feet to 50 or 60, balustrades, like steps, are proportioned to the size of the human figure, and in large buildings are relatively much smaller than in small ones. They thus serve, as do steps, and as does the human figure when introduced into a drawing, to indicate the scale of a building.

But in very large buildings balustrades have sometimes been made of colossal dimensions, that on the top of the front of St. Peter's, for example, being about 8 feet high.

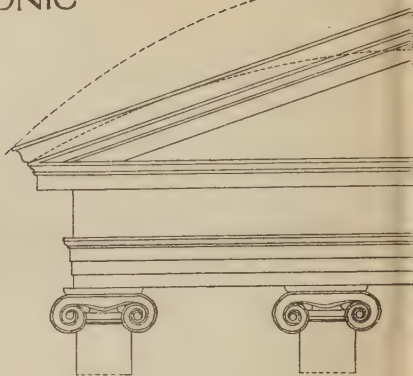
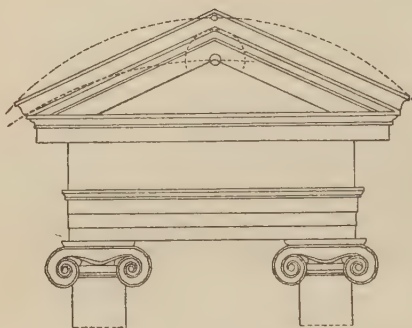
108. Attics.—When a parapet is placed on top of an entablature it is called an **attic**, Fig. 59 (*a*). Like pedestals, attics vary much in size and in architectural treatment. They are generally made about a quarter as high as the order below, and should not be more than a third. They should have a high plinth, or even a double plinth, as in Fig. 59 (*b*), so as not to be too much hidden by the projection of the cornices on which they stand.

As shown in Fig. 59 (*c*), the place of an attic is often taken by balustrades, which also should have high plinths below the lower rail.

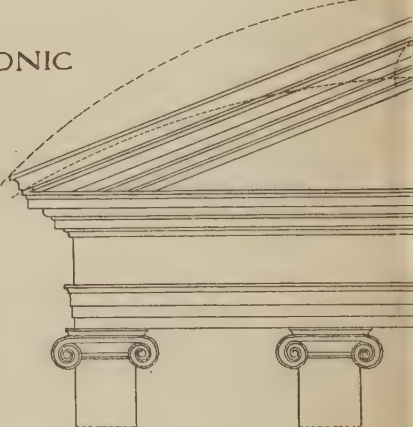
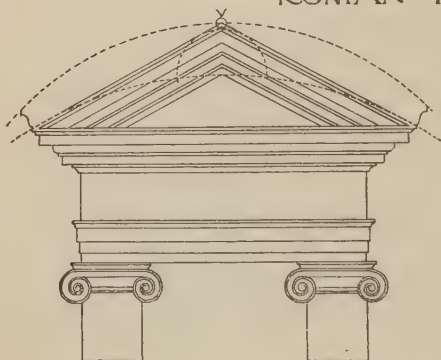
PEDIMENTS—PLATE XVI

109. The gable on a classical building, as in Fig. 61 (*a*), is called a **pediment**. It consists of a triangular piece of wall, called the *tympanum*, which is in the same plane as the frieze below; a *horizontal cornice*, which divides the tympanum from the frieze; and two pieces of inclined cornice that surmount the tympanum. The inclined, or *raking cornice* is like the cornice that crowns the wall on the sides of the building, but the cymatium is a little wider. The horizontal cornice has no cymatium, and generally terminates in a fillet, called the *split fillet*, which divides at the angle where the two cornices come together.

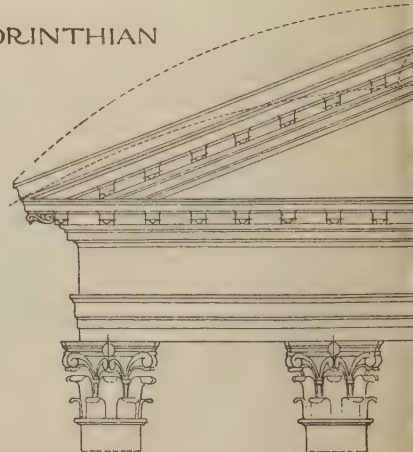
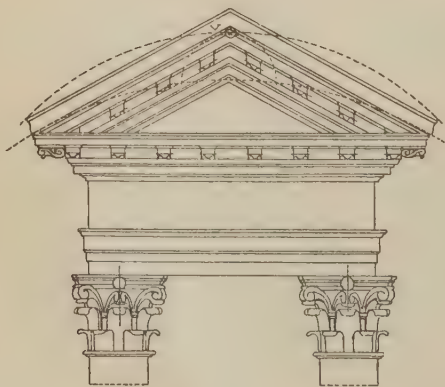
GREEK IONIC



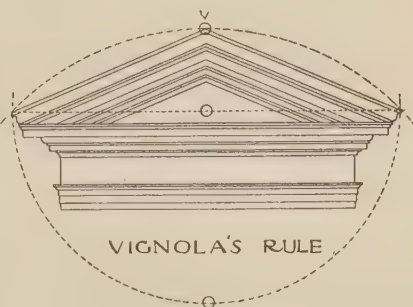
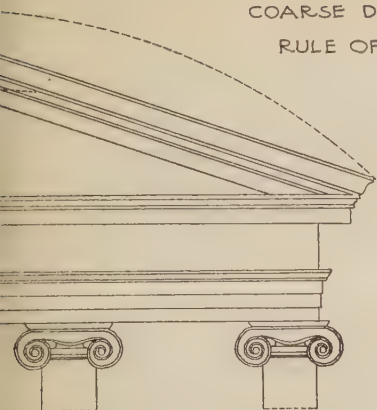
ROMAN IONIC



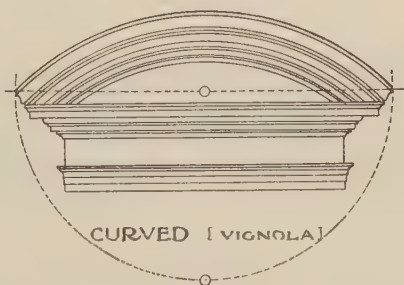
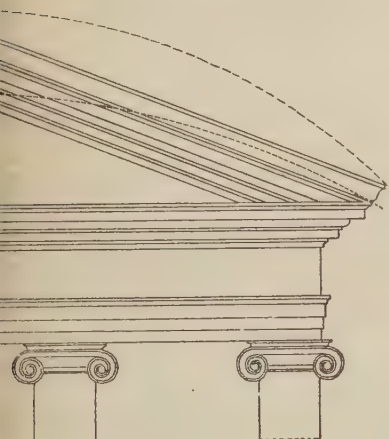
ROMAN CORINTHIAN



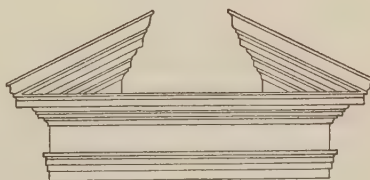
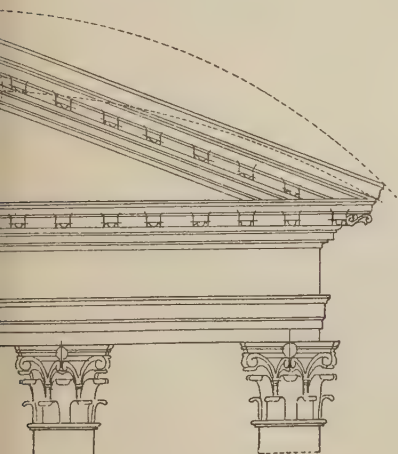
COARSE DOTTED LINE SHOWS
RULE OF "VIGNOLA"



VIGNOLA'S RULE



CURVED [VIGNOLA]



BROKEN PEDIMENT



If the cymatium is a cavetto, the under side of the fillet beneath it is beveled, either on the rake or along the wall; if it is an ovolo, the same thing happens to the fillet above it, as in Fig. 61 (*b*). With the cyma reversa, both occur; with the cyma recta, neither, the fillets having no soffit. This is one of the reasons for employing this molding in this place.

When a cyma recta is used in the cymatium, it occurs in four different forms, as shown in Fig. 61 (*c*), namely, (1) the profile of the molding along the wall; (2) the profile of the raking molding; (3) the line of intersection of these two moldings, which lies in a vertical plane, set at 45° ; and (4) the line of intersection of the two raking moldings at the top. The forms (1), (2), and (4) have the same projection but different heights, while forms (1) and (3) have the same height but different projections.

110. According to Vignola, the obtuse angle at the top of the pediment is included within an arc of 90° ; it accordingly gives a slope of $22\frac{1}{2}^\circ$. This is a good rule for most cases, but if a building is high and narrow, the slope needs to be steeper; if it is low and wide, the slope must be flatter. Inasmuch, however, as, for a building of a given width, the higher it is, the larger is the scale of the order employed and of all the details of the order, it follows that, for a given width of front, the larger the moldings are, the steeper must be the slope.

On this is founded the following rule for the slope of pediments, devised by Stanislas L'Eveillé: Taking the upper line of the horizontal cornice, Fig. 62 (*a*), as one side, construct below it an equilateral triangle; and taking the vertex of this triangle as a center, and its sides as a radius, describe an arc of 60° . Taking, then, the summit of this arc as a center, describe a circle, the radius of which is equal to the width of the horizontal cornice. Lines drawn from the extremities of the corona tangent to this circle will give the upper line of the raking corona.

It is obvious that the larger the cornice, relative to the length of the front, the steeper will be the slope. It is also

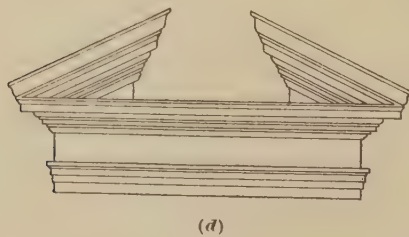
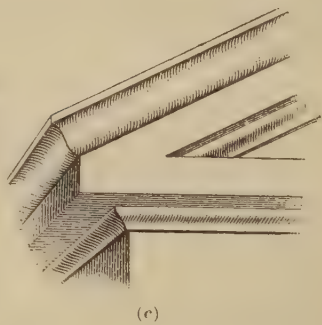
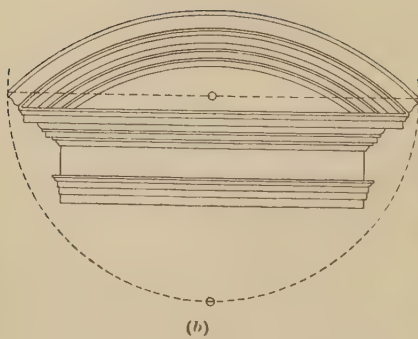
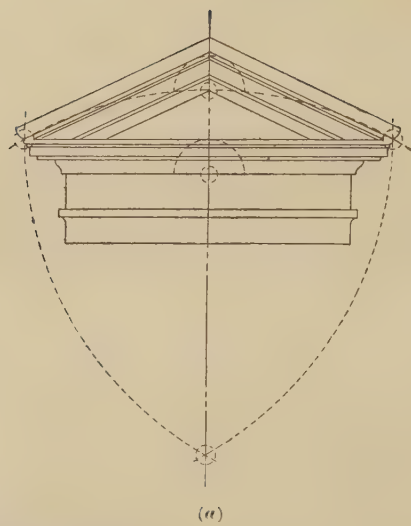


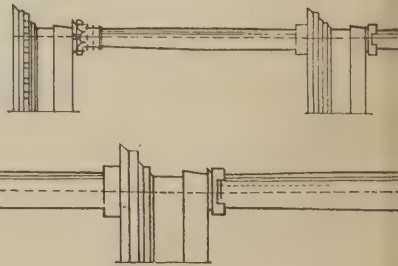
FIG. 62

SUPERPOSITION AND INTERCOLUMNIATION

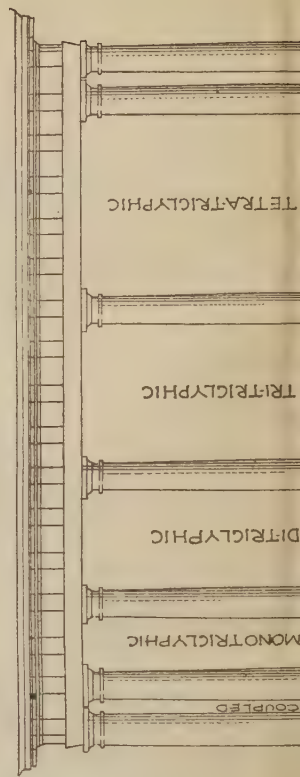
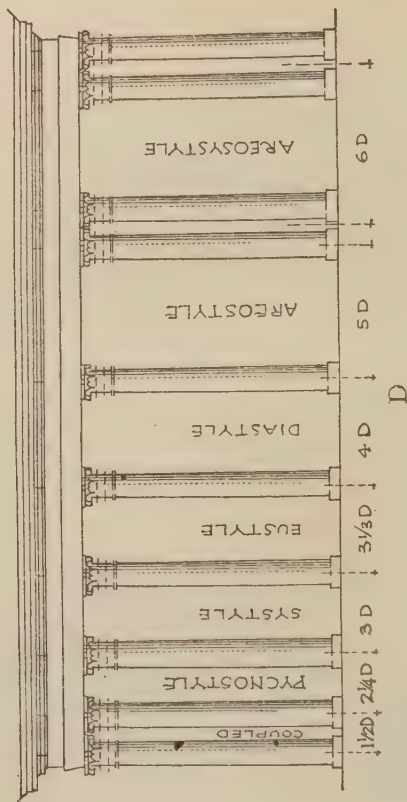
DIAMETER, THE SAME
IN EACH ORDER

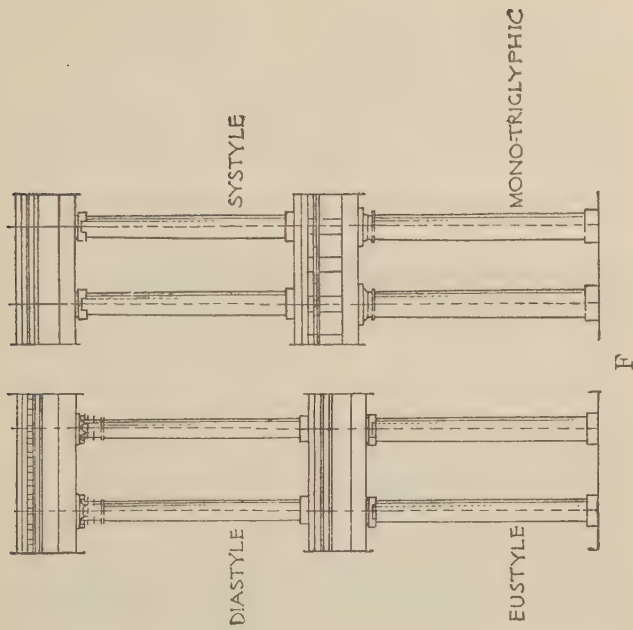
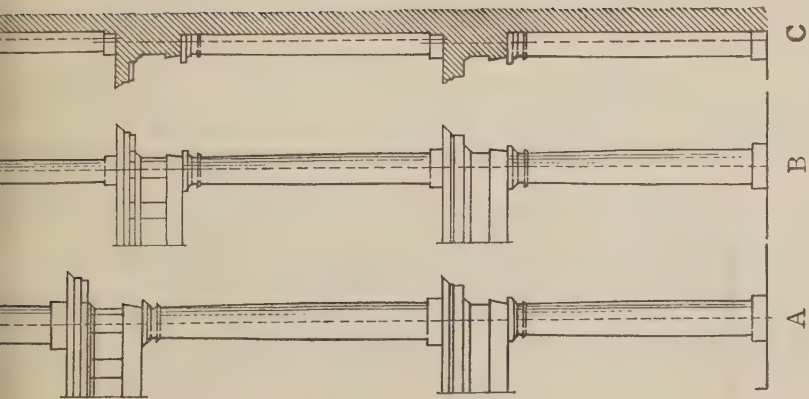


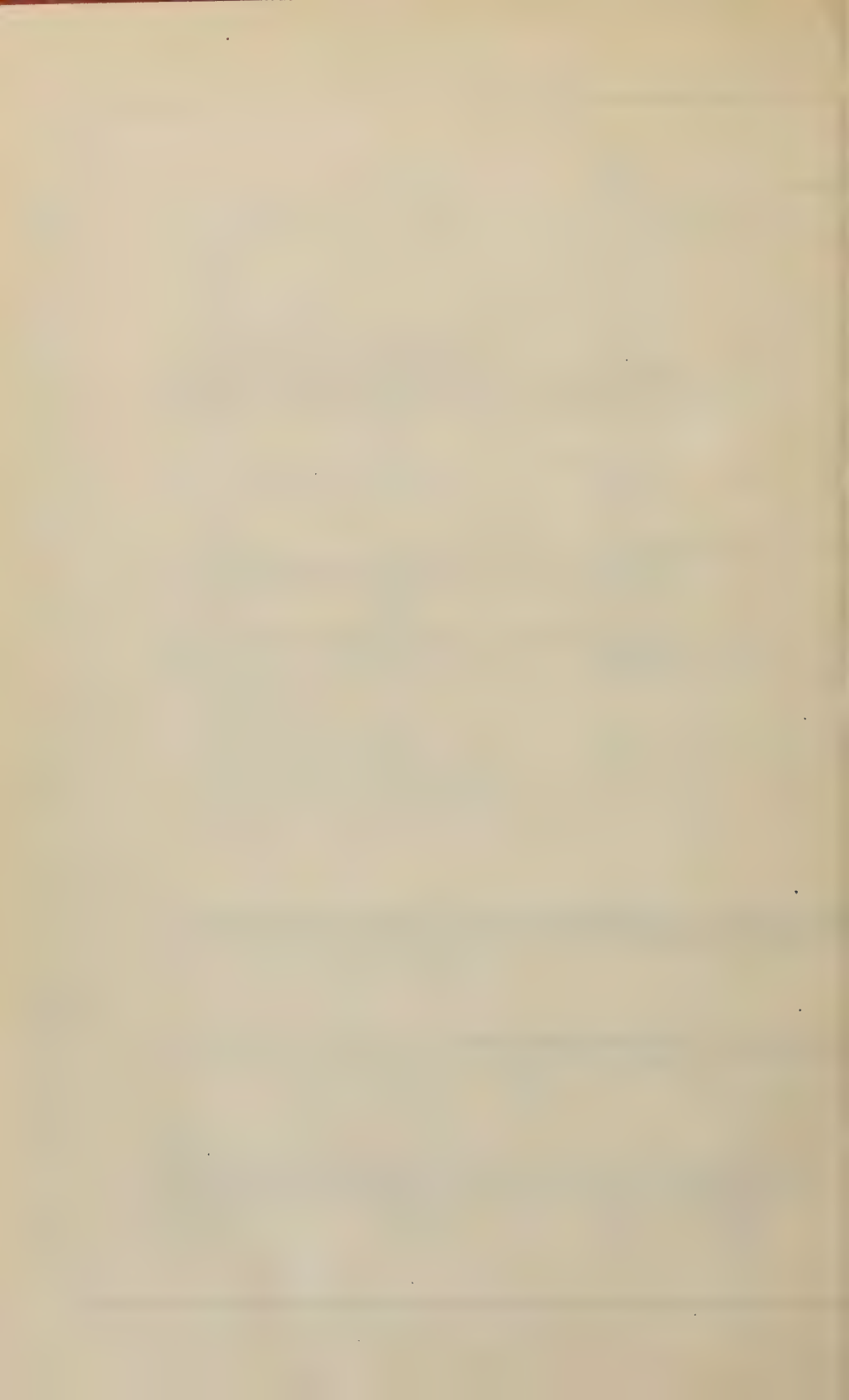
DIAMETER DIMINISHED
IN EACH ORDER



SECTION SHOWING AXIS
SET BACK IN EACH STORY







plain that this rule gives steeper pediments for the Corinthian and Ionic orders than for the Doric and Tuscan, and for the Roman orders than for the Greek, the cornices being wider.

Circular, or *curved*, *pediments* have a sweep of 90° , as in Fig. 62 (*b*), starting at an angle of 45° .

When pediments are used merely for ornament, the upper part is sometimes omitted, giving a *broken pediment*, as shown in Fig. 62 (*d*).

If the molding that crowns the corona is omitted, the faces of the three coronas are continuous, as shown in Fig. 62 (*c*).

INTERCOLUMNIATION—PLATE XVII

111. The space between the two columns, measured just above their bases, is called an **intercolumniation**. It is one diameter less than their distance apart on centers, or on edges.

Columns are said to be *coupled*, or to have a *pyncostyle*, *systyle*, *diastyle*, or *areostyle intercolumniation*, according as they are set close together, or are one, two, three, or four diameters apart, as nearly as may be; that is, about one, two, three, four, or five diameters on centers. The systyle and diastyle are the most usual, with an intercolumniation of two or three diameters. But coupled columns cannot be nearer than one and one-third diameters, on centers, instead of one diameter, on account of the projection of their bases, and in the Ionic, Corinthian, and Composite orders, not nearer than one and one-half diameters, on account of the projection of their capitals. The intercolumniation of coupled columns is accordingly made one-third or one-half of a diameter, or even a little more, so as to prevent the bases or caps from actually touching.

So also the pyncostyle intercolumniation is made one and one-fourth diameters instead of one diameter (that is, two and one-fourth diameters on centers, instead of two), to avoid crowding. The ancients thought that even the systyle columns, with an intercolumniation of two diameters, came

too near together, and preferred what they called the *eustyle intercolumniation*, of two and one-half diameters (or three and one-half diameters on centers in place of three diameters). But the moderns prefer to make the eustyle intercolumniation two and one-third diameters (setting the columns three and one-third diameters on centers), as this brings every

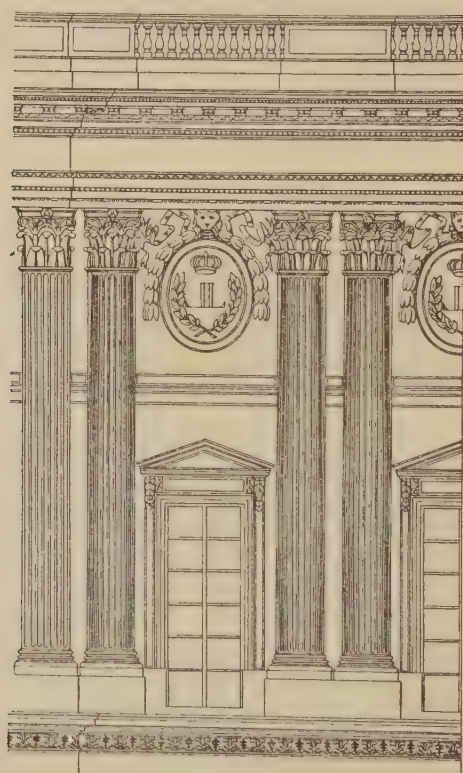


FIG. 63

column in Ionic and Corinthian colonnades exactly under a dentil, and every alternate one just under a modillion, the dentils being one-sixth of a diameter on centers and the modillions two-thirds of a diameter.

112. The wider intercolumniations are preferable, obviously, when the columns are small, since otherwise it might

be difficult to get between them; and the systyle, or even the pycnostyle, when the columns are very large, since otherwise it might be difficult to find stone architraves long enough to span the interval. But the ancients used Tuscan columns chiefly with wooden architraves, setting them as much as seven diameters apart, which is called *Tuscan intercolumniation*, and which makes the space between the columns about square. In modern times, also, an arrangement of coupled columns, called *areosystyle*, has been employed, the columns being set half a diameter apart and the space between the pairs of columns made three and one-half diameters. This is greater than the diastyle intercolumniation and less than the areostyle by half a diameter. From the axis of one pair of columns to that of the next pair, the distance is six diameters. If, in a systyle colonnade with the columns three diameters on centers, the alternate columns are moved along until they nearly touch the intervening ones, the result is an areostyle colonnade. This was first used by Perrault in the eastern colonnade of the Louvre, as shown in Fig. 63.

In actual practice these rules for intercolumniation are seldom exactly followed, as circumstances vary their application.

113. Doric Intercolumniations.—In the Doric order, since the columns come exactly under the triglyphs, and the triglyphs are one and one-fourth diameters on centers, as on edges (the width of the triglyph being one-half of a diameter and that of the metopes three-fourths of a diameter), the distance of the columns on centers must be a multiple of one and one-fourth diameters.

This makes the coupling of Doric columns difficult, since, even if the bases touch, the distance between axes is still one and one-third diameters, which is more than that of the triglyphs by one-twelfth of a diameter. This slight discrepancy can, however, be got over by making each base a trifle narrower, or the triglyphs and metopes a trifle wider, or by putting the columns not exactly under the triglyphs, or by employing all these devices at once.

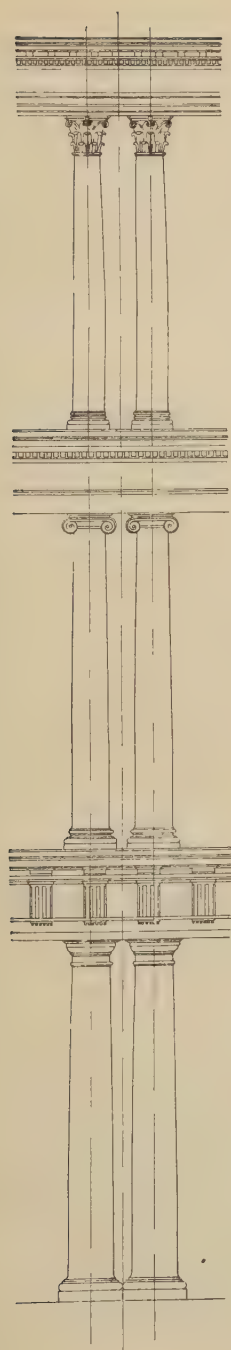
114. If the columns are set under alternate triglyphs so that there is one triglyph over the intervening space, their distance apart o. c. is two and one-half diameters. The intercolumniation is then one and one-half diameters, and is said to be *monotriglyph*. This is the most common arrangement. But if the scale is small, it is customary, at least at the principal entrance of a building, to have two triglyphs over the opening, the columns being three and three-fourths diameters on centers. The intercolumniation is then two and three-fourths diameters, and is called *ditriglyph*. Still wider spacing is employed when the architraves are of wood.

When two, four, six, eight, ten, or twelve columns are used in a colonnade or portico, it is said to be *distyle*, *tetrastyle*, *hexastyle*, *octastyle*, *decastyle*, or *dodecastyle*, according to the Greek numerals. Examples are found at Argos, Assos, Thoricus, and Pæstum of façades with an odd number of columns, three, five, seven, and nine, a column instead of an intercolumniation coming on the axis, giving *tristyle*, *pentastyle*, *heptastyle*, and *enneastyle* porticos. But in all these cases the entrances were apparently on the sides of the buildings, where there was an even number of columns.

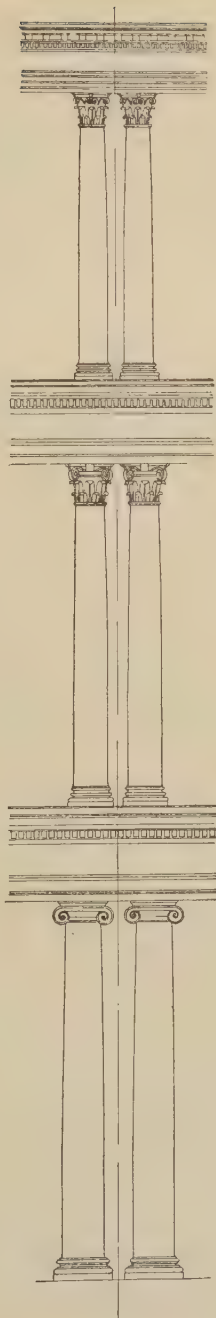
SUPERPOSITION—PLATE XVII

115. **Superposition** is the placing of one order above another, as in the Roman amphitheaters and in many modern buildings of several stories. The more solid forms of the Tuscan and Doric are naturally placed below and the Ionic and Corinthian above. As the Composite is more vigorous, it is sometimes placed below the Corinthian. But in high buildings it is generally placed on the top story, its large details being better seen at a distance than are those of the more delicate order.

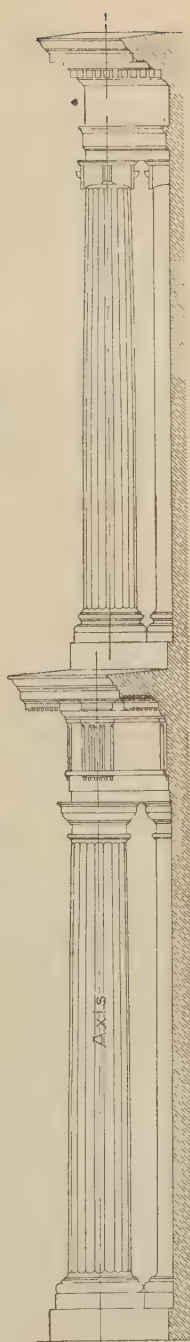
Even when the same order is employed in the different stories, it is advisable to have the upper columns of smaller diameter than those below and all the dimensions diminished accordingly, for the sake of lightness. But it is still more important to do this when different orders are superposed,



(a)



(b)



(c)

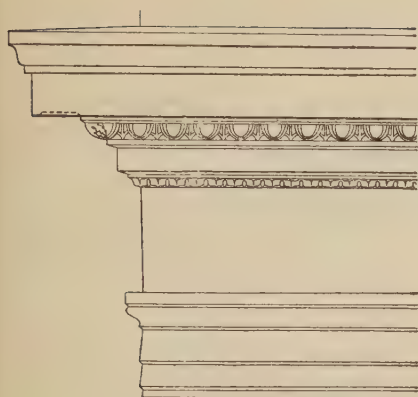
for otherwise the Doric and Corinthian stories would overpower the Tuscan and Ionic ones beneath. It is customary, accordingly, to make the lower diameter of each shaft equal to the upper diameter of the shaft below it, as if they were all cut from a single piece of tapering stone. This makes the scale employed in the second story five-sixths of that used in the first; in the third, twenty-five thirty-sixths, or about two-thirds; in the fourth, about three-fifths; and in the fifth, about one-half, if the five orders are employed in regular sequence. This makes the relative height of the orders in the successive stories to be as 7, $6\frac{2}{3}$, $6\frac{1}{4}$, $5\frac{5}{8}$, and 5, very nearly. The actual height of the stories themselves may be somewhat modified by the use of plinths and pedestals.

116. This system of superposition makes the distance apart of the columns in each story, when expressed in terms of their own diameter, six-fifths of that in the story below. A eustyle intercolumniation in one story thus exactly produces a diastyle intercolumniation in the story above, and a Doric monotriglyph intercolumniation, a systyle.

$$\left(\frac{6}{5} \times 3\frac{1}{3} = 4; \frac{6}{5} \times 2\frac{1}{2} = 3\right)$$

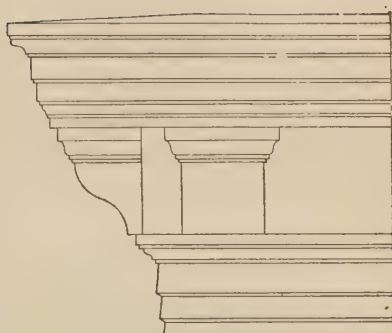
Coupled columns set one and one-third diameters apart, on centers, in one story, are, in the story above, one and three-fifths diameters on centers, and in the third story nearly two diameters on centers. This does very well for a sequence of Doric, Ionic, and Corinthian, as in Fig. 64 (*a*), but if the lower columns are Ionic or Corinthian, those above had better be set nearer together, the axis of the intercolumniation only being preserved, as shown in Fig. 64 (*b*).

With this exception, superposed columns are set so that their axes are in the same vertical line, when seen in elevation. But in profile, as seen in section, the upper ones are set back, the wall against which they stand generally growing thinner as it goes up, as shown in Fig. 64 (*c*). Since the columns themselves also grow smaller, it would not do to leave too much space behind them. The slightly pyramidal effect that this gives to a building of several stories is of value, as it prevents the building from looking top-heavy.



From the Pantheon, Rome

(a)



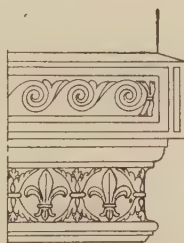
From the Fourth Order of the Coliseum

(b)



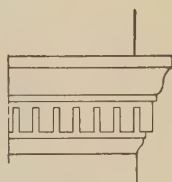
From the Villa Caprarola,
by Vignola

(c)

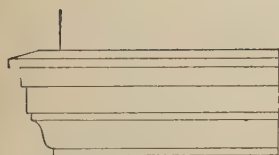


From the Farnese Palace
By San Gallo

(d)



(e)



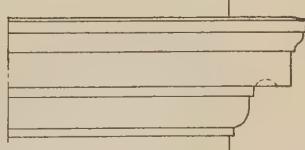
String-Course from the Strozzi Palace

(f)



String-Course from the Palazzo Giraud
By Bramante

(g)



String-Course from the Sacchetti Palace
By San Gallo

(h)

FIG. 65

OTHER STYLES OF CORNICES AND STRING-COURSES

117. The five orders worked out by Vignola are generally accepted as a standard, though they are seldom exactly followed in practice, modern as well as ancient examples exhibiting a great variety in the forms and proportions of the parts. But familiarity with them is of great service in designing, since they can safely be employed on all ordinary occasions and in the earlier stages of architectural composition. Other types of nearly equal merit have been published by Alberti, Palladio, Serlio, Scamozzi, Sir William Chambers, and others, and a great variety of cornices, both with and without friezes and architraves, have been employed in ancient and modern times to crown and protect walls that were not decorated with columns or pilasters.

118. Many of these show blocks or modillions without any dentil course below, as on Palladio's composite cornice, and in many of them the dentil course is plain, forming what is called an *uncut dentil course*, as shown in Fig. 65 (a). In others, the brackets that support the corona are brought down so as to occupy the frieze, as in Fig. 65 (b). The most important of these is Vignola's so-called *cantilever cornice*, Fig. 65 (c), used by him at Caprarola. It seems to have been suggested by the mutules and triglyphs of his mutulary Doric.

Cornices, and indeed full entablatures, are often used as string-courses to separate stories, as in the Roman amphitheaters. However, it is customary to use instead a lighter form of small projection, somewhat like the cap of a pedestal, in which the cymatium and bed mold are often omitted and the corona itself sometimes diminished to a mere fillet, as in Fig. 65 (d), (e), (f), (g), and (h).

EXERCISE II

1. What is composition in architecture?
 2. What is the difference between (a) repetition and continuity in designs? (b) Repetition and alternation?
 3. (a) What is the purpose of moldings in architectural composition? (b) How may the same result be obtained without moldings?
 4. How may architectural proportions be approximated through the use of diagonal lines?
 5. Make a drawing of the complete Doric order with entablature and pedestal based on a column whose diameter is $1\frac{1}{2}$ inches.
 6. Make a drawing of a Corinthian capital for a column whose lower diameter is four inches.
 7. Make a drawing of the entablature of the Ionic order, wherein the column is two inches in diameter.
 8. Make a drawing of a Greek Doric column and entablature based upon a diameter of two inches for the column.
 9. Make a drawing of four Ionic columns, one inch in diameter, grouped under a pediment.
 10. State the conditions that govern the designing of columns in intercolumniation and superposition.
- 5, 8, and 9 to be on sheets 12 in. $\times$ 18 in., 6 and 7 to be on sheets 9 in. $\times$ 12 in. All sheets to have a border $\frac{1}{2}$ inch wide all around, with the title neatly lettered within the border in some suitable space. Above the border the problem number to be lettered on the left and the sheet number on the right. Below the border, the date of completion to be lettered on the left, the name and class letters and number on the right, and the number of hours consumed in executing the drawing in the center. All drawings to be executed in pencil, but the border and exterior lettering may be in ink. When complete the large sheet to be folded once across and enclosed in the proper envelope with the small sheets and mailed to the Schools for criticism.



(a)



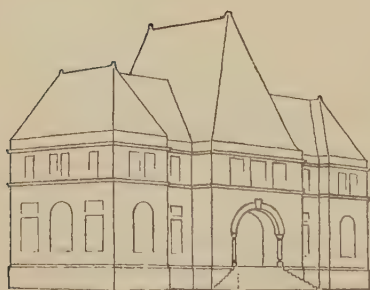
(b)



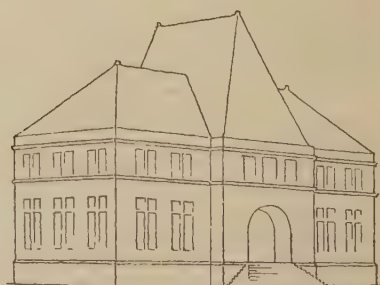
(c)



(d)



(e)



(f)

FIG. 66

APPLICATION OF PRINCIPLES

ANALYZING OF EXISTING DESIGNS

119. After a careful study of the principles of architectural composition and proportion, it is well to be ever on the lookout for buildings that express various groupings heretofore referred to, and also to analyze them and try to decide whether the treatment is the best that could be accomplished. By thus taking advantage of the better groupings he observes and avoiding the unsatisfactory ones, the student will instinctively select a system to govern his own designs. A memorandum book in which sketches of good examples of architectural grouping can be made from time to time will also be of great value, as he can then work up these sketches at his leisure and experiment with the designs in the endeavor to improve on them.

120. Take, for example, the building shown in Fig. 66 (*a*). Here is expressed a group of three—two pavilions connected by a link to the central gabled mass, which is the most important. With a sketch of this laid out as at (*a*), the variations can be studied by means of a piece of tracing paper. This paper can be laid over the design so as to sketch out the principal details, and then their grouping can be experimented with.

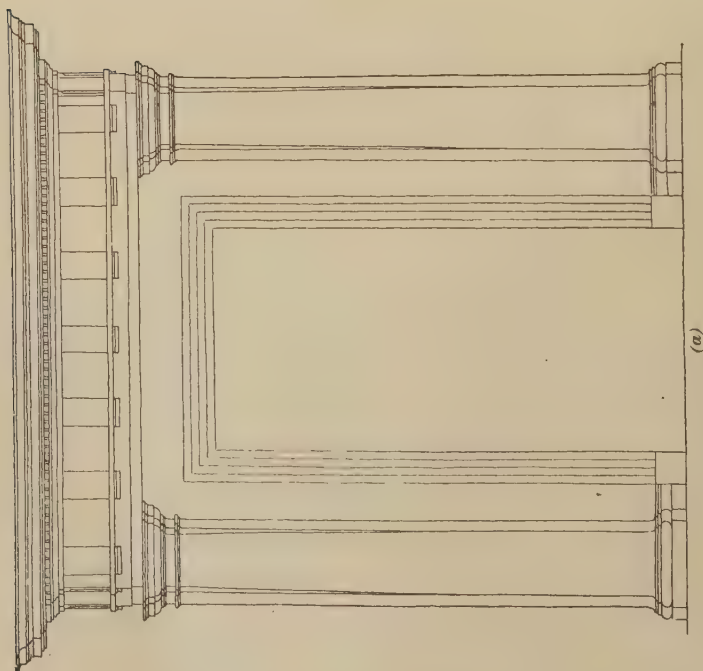
The fundamental base from which this design is evolved is shown in (*b*). Here is expressed a single mass, with its windows grouped to suit the requirements of the interior, and a roof over the whole. There are no dormers or other openings above the cornice, so that almost any liberty can be taken with the roof composition to secure a desirable effect. The grouping in (*a*) is not wholly satisfactory, as there is too much uniformity in the masses. The central

mass, though larger than the other two, does not seem to dominate them sufficiently. A group of two with a connecting link, as shown in (*c*), might be better, but the pavilions seem to be too narrow in proportion to the link connecting them; and by increasing their width, as at (*d*), the treatment adds to the importance of the two pavilions, while according to the original building, in (*a*), it is evident that the central mass should be the most important. The central mass should therefore be increased in importance, as its lack of assertion is the chief fault of the original composition. By raising the roof and hipping it back, as in (*e*), this effect is attained, and there is no longer any doubt as to the importance of each mass. The secondary masses, however, have lost in value through the increase in importance of the central mass, and if this is at variance with the purposes of the design, it might be well to suppress the secondary masses entirely and treat the composition as a single mass with two auxiliary masses, as shown at (*f*).

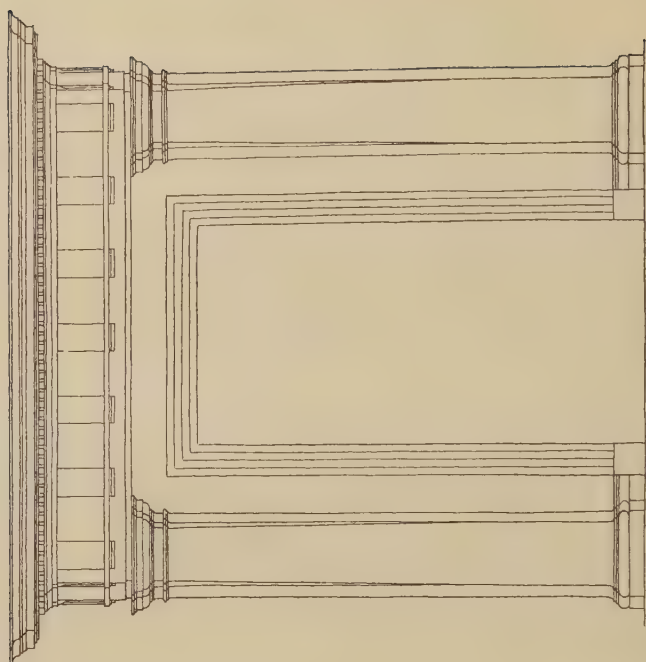
Here, then, are shown six methods of treatment that do not affect the plan materially and depend for effect mostly on the handling of the roof. A slight variation of the window openings would be necessary in some places, but no change great enough to require any alteration of the plan. Such a design is susceptible of almost unlimited changes, and frequent exercises of this kind afford excellent practice for young designers.

INTERCHANGING OF ORDERS

121. Another practice that should be indulged in frequently is the interchange of the classic orders. For example, make a drawing from a photograph of some such building as the Vendramini Palace or the Gaston d'Orleans wing of the château at Blois, but substitute some other order for the one in the original design and alter the design accordingly. The diameters of the columns will determine their lengths, and this will influence the heights of the stories; or, if the diameters are varied to suit the lengths assumed, the change will affect the spacing of the windows.



(a)



(b)

FIG. 68

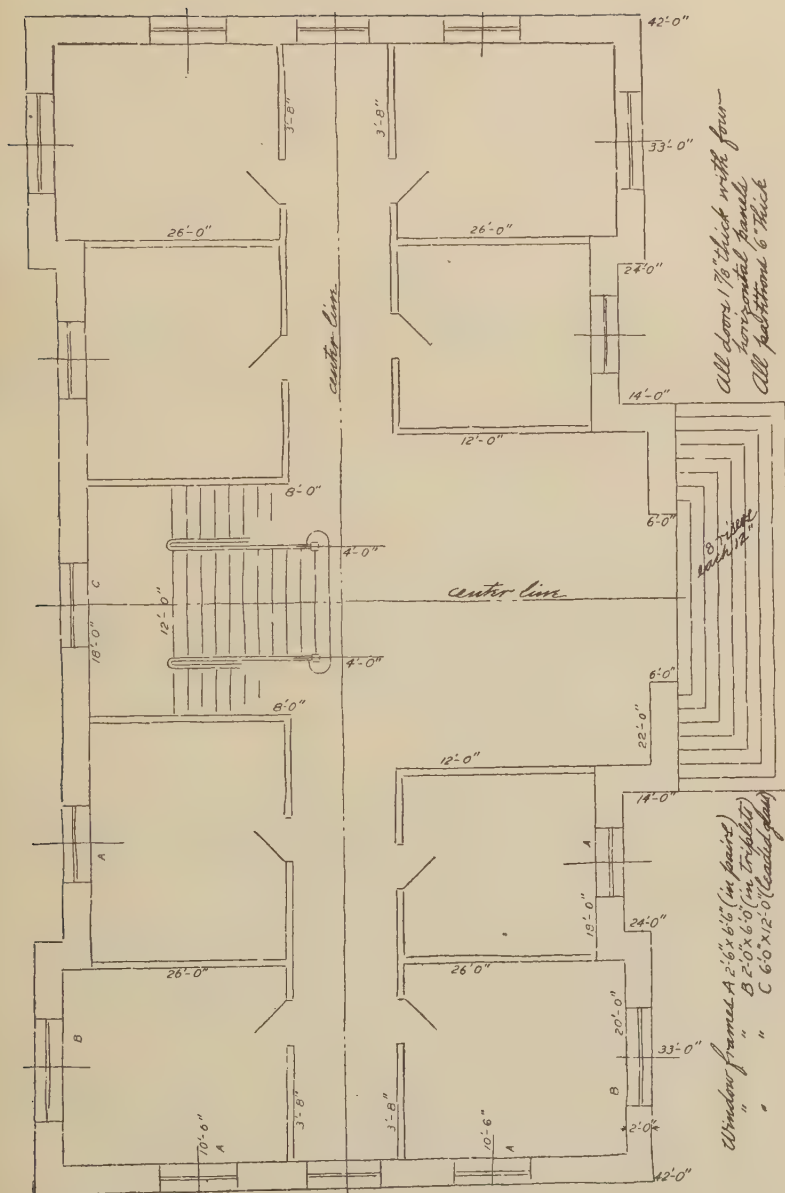


FIG. 69

As only the diameter of the column has to be known in order to draw out the entire order, the beginner can construct the elevation of a building from a brief description. The student should write out descriptions of buildings that he frequently sees, and then endeavor to make a measured drawing of a building from the description he has written. He should also take the opportunity as frequently as possible of actually measuring up a building and then laying out a drawing of it. If an entire building is too great an undertaking, he should select a detail of it, such as the entrance, a window, a gable, or some other section.

122. Measuring Up.—In measuring up a building for the purpose of making an actual drawing, everything should be figured from a given point, as this will render errors in measurement less likely to affect the entire drawing. If each detail is measured separately, a single error is likely to throw all the details out of place.

In Fig. 67 (*a*) is shown a rough, freehand sketch of a doorway, of which all the measurements have been taken from two given base lines. All the vertical measurements are taken from the floor, while all the horizontal measurements are taken from the center line of the left-hand column. In (*b*), however, the same doorway has each member figured separately, and there is an error in the figures showing the space between the door head and the entablature of the order. If a drawing were to be made from this figured sketch, all the details above the door head would be out of place, as shown in Fig. 68 (*a*); whereas, if a drawing were made from Fig. 67 (*a*), and the same error existed, the only detail out of place would be the lower line of the entablature, and this would soon show itself, because the architrave would appear too narrow.

123. The same method should be followed in surveying or measuring up the plan of a building, whether for alterations or for the purpose of making a diagram of it. In Fig. 69 is shown a rough sketch of a floor plan. Two center lines are taken on the axes of the two corridors, and

the partitions are figured on each side of these axes. The dimensions of the window and door openings are then taken separately, and a written memorandum is made of the details of each. Where lighting fixtures exist, they can be located by figures showing the distances of the outlets from two walls of the room, or, where the outlets are in the side wall, they can be figured from the nearest wall and from the floor. Radiators can be drawn in place and the position of the riser pipe figured, while plumbing fixtures need simply to be indicated and the standing lines located with figured dimensions. Where more detail is required, such as the form and character of the trim, separate sketches should be made and all the moldings carefully profiled.

The axis from which the general measurements are taken need not be in the center of the structure, but can be located at any convenient place from which all measurements can be easily made. If the axis is changed for any reason while the survey is progressing, the new line should be carefully figured relative to the old one, so as to avoid errors. If measurements are found to have been omitted, and a return to the building becomes necessary, the additional figures should be put on the first sketch, thus avoiding the annoyance of handling two or three memoranda while plotting the plan.

124. The beginner should cultivate the habit of observing the details of the design of any building. This habit is best acquired by attempting to write out a complete description of the building from a photograph or from the edifice itself, and then to make a drawing of the structure from the description as written. Any omission of important details will at once become evident, as the drawing cannot be completed without them. For example, take the Arch of Titus, Fig. 84, *History of Architecture and Ornament*, Part 1. A description of it would be somewhat as follows:

A triumphal arch consisting of a mass of masonry pierced with a single arched opening, and embellished with attached columns, pedestals, and entablatures of the Composite order.

The entire width of the monument measured between the center lines of the outside attached columns is twenty diameters of one of its columns, and is arranged as follows: On each side of the opening stands a mass of masonry that together support the superstructure. At the sides of these masses are attached columns five diameters apart, on centers. A continuous pedestal on which the columns rest extends across the face of each flanking mass, and an entablature above the columns extends across and around the entire monument from one mass to the other. This entablature breaks out and returns around the end columns, but breaks out entirely across the space over the arch between the two flanking masses. Above the entablature is an attic, or superstructure, bearing an inscription tablet. This attic is about one-third the height of the entire mass below it, is molded like the pedestal, but has pilasters broken out on each end, corresponding to the broken entablature below, and a tablet raised in its center, corresponding in width to the archway of the monument.

In the center between the two flanking masses is an arch with an architrave around the face of the vault between the imposts, supported on two pilasters that project into the opening about three-fourths of a diameter beyond the lower part of the columns. The height of the arch in the center is one and one-half times the width between the pilasters, and a keystone in the center extends up to the under side of the horizontal architrave of the order. The astragal of the capitals of the columns is carried across the flanking masses of masonry between the columns.

This description will be found sufficient for making a drawing of the elevation of the Arch of Titus shown in Fig. 84, *History of Architecture and Ornament*, Part 1. Any assumed dimensions can be taken as the diameter of the columns, and the design can be worked out from the proportions of the Composite order and the dimensions given.

EXERCISE III

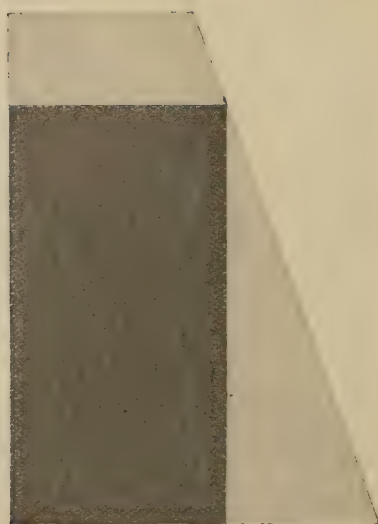
1. **Sheet I.**—On a scale of $\frac{1}{4}$ inch to the foot, draw a Roman Ionic temple in accordance with the following description: The plan shows four columns across the ends and seven down the sides. The columns are 2 feet 6 inches in diameter, and are spaced three diameters apart, center to center. The bases of the columns stand on a *podium*, or continuous pedestal, extending entirely around the temple, except in front, where it is broken to permit a flight of steps to the floor of the temple, which is even with the top of the podium. The width of the steps across the front is seven and one-third diameters, and nine of them are required to reach the floor level of the temple. The naos, or cella, of the temple is shorter than the columnar enclosure, as the roof is carried out two columns beyond the front so as to form a pronaos, or porch. — The cella therefore is nine diameters wide and fifteen diameters long, and the columns on the sides and rear of the temple are attached to the walls, making the structure pseudoperipteral.

2. **Sheet II.**—Draw the front elevation of the preceding temple, showing a pediment over the entablature and an entrance between the central columns six diameters high.

3. **Sheet III.**—Write a complete description of any one of the following buildings so that a drawing can be made from it: Colosseum; Arch of Constantine, Rome; Petit Trianon; Madeline, Paris; Banquet Hall of Whitehall Palace, Royal Exchange, London.



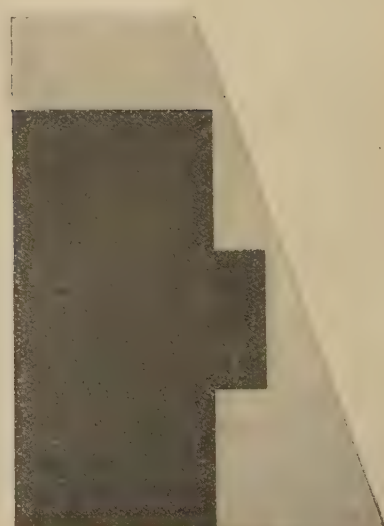
(a)



(b)



(c)



(d)

FIG. 70

PROBLEMS IN DESIGN

125. Designs for monumental and important buildings are usually laid out in accordance with certain required conditions that constitute the problem that the architect is called on to solve. These requirements are never twice alike, so that every problem that confronts the architect is a new one, but practice and experience make each solution simpler, so that as soon as the conditions of the problem are stated, the experienced architect conceives an idea of the way he will set out to solve them. The various architectural magazines publish from time to time advertisements of competitions for various public buildings, and the beginner should occasionally procure the conditions of these competitions and experiment in planning. His solution of the problem should then be compared with the accepted plans, which are sure to be published sooner or later. A few of these problems and their solution will serve to illustrate the process by which the final results are obtained.

126. Problem in Design of a Bank Building.—A large and important banking corporation desires to erect a new and imposing building to be used solely for its own purposes. Provision is to be made for eight tellers' windows for the transaction of ordinary business, and for at least four extra windows for emergencies. There are to be private offices for the president and the cashier, each to be about 225 square feet; a board-of-directors' room of not less than 350 square feet; a coat room and a lavatory for the clerks and bookkeepers; and separate toilet rooms for the officers and customers. At some convenient spot accessible to all the officers and tellers, a fireproof vault is to be provided, the floor area of which is to be not less than 100 square feet. The building will stand on a corner lot 50 feet wide in front, 140 feet deep, and 100 feet wide in the rear. The front wall must be 25 feet back of the building line on the 50-foot front, and 10 feet back of the line on the 140-foot side. The lot is not rectangular, but of the form shown in

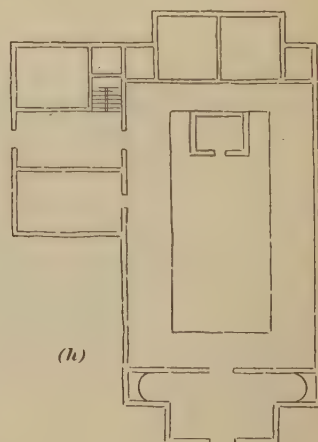
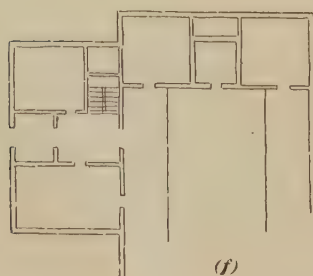
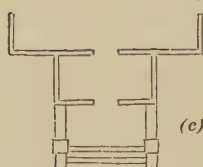
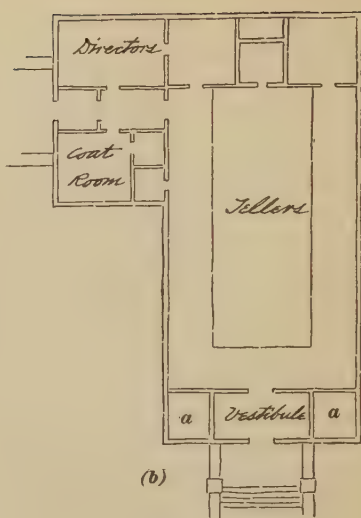
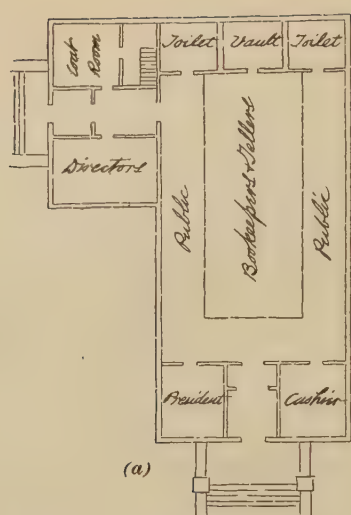


FIG. 71

Fig. 70 (*a*). The arrangement of the parts and the exterior treatment are left entirely to the discretion of the architect.

127. The first problem arising in the arrangement of this plan is the placing of the tellers' windows so that they will be easily accessible to the public. This problem presents two solutions: the windows can be arranged around the walls, so as to get the benefit of plenty of light, with a large open space in the center for the use of the public; or, they can be placed in the center with a passageway around them. The latter treatment demands a skylight, but it enables the entire clerical force to be together, and is therefore desirable in this case.

128. Since the plot on which the building is to be erected is irregular in shape, it is hardly practicable to have the walls of the building conform to it in plan. The largest rectangular plan that can be erected on the plot, within the 25-foot reserve, is shown in Fig. 70 (*b*), but this leaves a large triangular space of unused ground that does not enhance the building any, as its greatest depth is toward the rear. The most conspicuous angle of the building would be that at the intersection of the two streets, and it would be well if the excess space were at that end.

A wing forming an auxiliary mass can be carried out from the main structure, as in (*c*), thus reducing the size of the triangular waste space, or if a symmetrical plan be demanded, a wing can be carried out from the middle of the side, as in (*d*), but this leaves matters quite as bad as they are in (*b*). The scheme shown in (*c*) would leave a triangular plot embraced between the wings of the building, which could be rendered pleasing in connection with the exterior treatment, and a porch on the side pavilion could be made to utilize the major part of the other triangle. If space would permit, however, and a smaller area would satisfy the demands of the problem, all walls could be drawn back from the lot lines and a small grass strip could be carried around the two sides, as shown by the white space in (*c*).

129. All the suggested arrangements are necessities dependent on the working out of the plan, but starting with the scheme shown in Fig. 70 (*c*) as a basis the rough arrangement is sketched out as shown in Fig. 71 (*a*). Here, the offices for the president and the cashier are placed on each side of the entrance. The vault is placed against the center of the rear wall, with toilet rooms each side, while the enclosure for the clerical force and tellers is railed off in the center. The directors' room and other details work out nicely in the wing, but the tunnel-like vestibule detracts from the impressiveness of the entrance. Reversing the plan, and placing the officers' rooms in the rear, as in (*b*), improves matters so far as the entrance is concerned, but it necessitates the changing of the toilet rooms to the wing and creates two spaces *a* that are apparently of no use.

The spaces *a* could as well be removed, thus giving a projecting entrance and leaving more grass space around the prominent angle. Studying this entrance by itself, as in (*c*), after the removal of the angles *a*, develops the fact that the vestibule is still too small for so impressive an interior. Enlarging the vestibule by itself, as in (*d*), renders the projection excessive, and it is found advisable to resort to a compromise of the arrangement shown in (*b*) and plan the entrance as in (*e*). For the present, this can be left and the rear studied out more carefully.

130. The arrangement shown in Fig. 70 (*b*) is likely to leave the back rooms gloomy and unventilated, except through the skylight. The wing can be moved forwards as in (*f*), so as to get a window in the president's office, but there is still no ventilation for the cashier's office. This suggests breaking the angles as in front and placing the offices directly adjacent, as in (*g*). The vault is now removed from the rear and built entirely within the building. This is an advantage, as being exposed on all sides, the vault secures additional burglar protection. The public toilet rooms fall naturally in the angles of the building, as shown, and all promises to work out well.

The wing can now be divided to provide a coat room and a lavatory for the clerical force. The directors' room will open into the banking room, and the stairway to the basement and to the janitor's quarters can be fitted between the coat room and the main structure, as in (*h*). The vestibule can be worked out to include a couple of niches for statuary where the waste

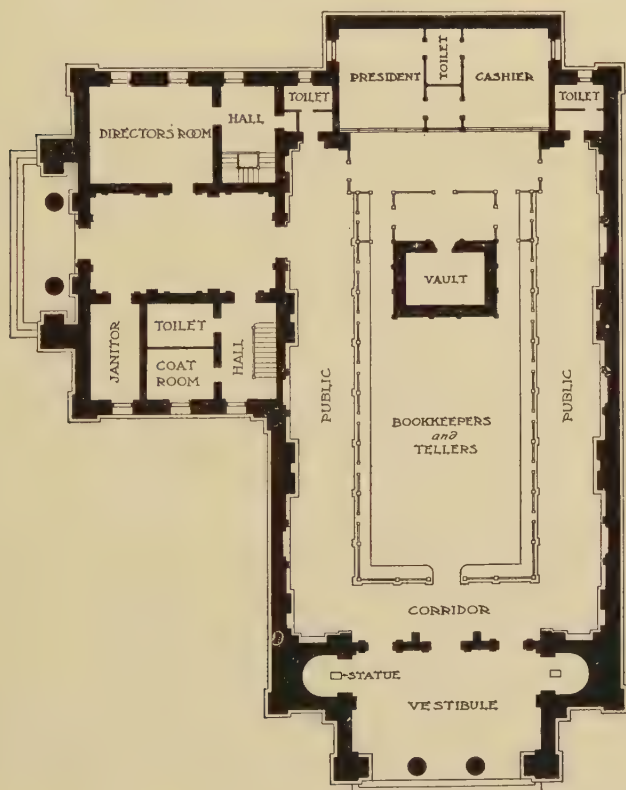


FIG. 72

spaces were formed, and everything being approximately satisfactory the whole can be laid out to scale as in Fig. 72.

The offices of the president and the cashier are 16 ft. $\times$ 16 ft. each, or 256 square feet. The directors' room is 14 ft. $\times$ 26 ft., or 364 square feet. There is ample room for the

tellers and clerical help, and the plan can be left in this state while the elevations are being worked out.

131. Fig. 73 shows a rough sketch for the main front. It is a simple, classic treatment with a projecting porch, and seems in every way to be in keeping with the dignity of the design.



FIG. 73

The lighting of the interior can be provided either by means of a skylight in the center or by openings in the parapet wall around the hipped roof, according to which scheme works out with the development of the design.

Details of the elevations must be sketched and re-sketched, precisely

as was done with the plan, and more changes then made in the plan where necessary to permit the best combined conditions. The columnar treatment of the portico suggests a similar interior treatment, and note of this must be made on the plan.

In Fig. 74 is shown a sketch of an elevation of one side of the interior. This decorative scheme requires that the pedestals under the pilasters shall be shown in the plan, as well as the projection of the main pilasters and inferior order supporting the pediment over the tablets. The position of these details is therefore indicated in the plan, Fig. 72.

Finally, the entire problem is worked out and the final plans and elevations are made and rendered, as shown in Figs. 77 and 78.

132. Dwelling Houses.—It does not always follow that the simpler and more modest the problem, the easier

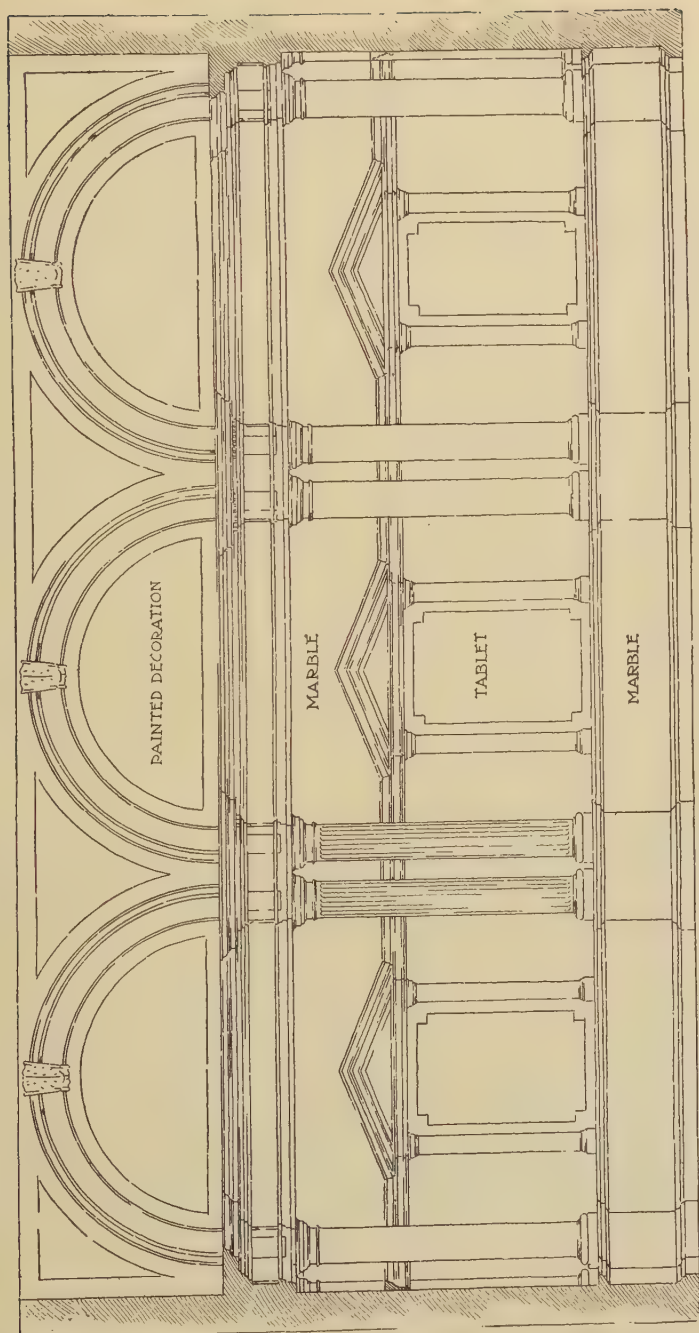


FIG. 74

it is to work out. On the contrary, there are some small problems exceedingly difficult to solve in a satisfactory way. Among these is the low-priced frame residence. Such a dwelling must have a kitchen, a dining room, and a living room on the first floor, a bathroom and sleeping rooms on the second floor, and a certain amount of attic room. To get all these rooms within the limits of the set cost is often difficult and frequently impossible. A good way to plan within these limitations is to determine at the outset what the plan area shall be. This can be done by assuming that the class of dwelling required costs a certain amount per cubic foot, and then dividing this amount into the building-limit price, in order to determine how many cubic feet can be enclosed within the proposed residence. This total of cubic feet divided by the average height of the building will give the plan area.

For example, a house containing two stories and an attic is to be built for \$4,000. As a rule, the first-story ceiling should be at least 10 feet in the clear and the second-story not less than 9 feet, while the attic should be 8 feet and the cellar 7 feet. Allowing 12 inches to the thickness of each floor between the stories will give a total of 38 feet for the height of the building from the cellar floor to the top of the attic ceiling beams. Now, assuming that this class of dwelling can be built at 10 cents per cubic foot, for \$4,000, it will be possible to build 40,000 cubic feet, and $40,000 \div 38 = 1,053$ square feet. The next process is to try to arrange the required rooms of the required sizes within the required area. Assuming the dining room to be 12 ft. $\times$ 16 ft., or 192 square feet, the kitchen, 12 ft. $\times$ 14 ft., or 168 square feet, and the living room 15 ft. $\times$ 20 ft., or 300 square feet, there is in all 662 square feet of plan, thus leaving 391 square feet for halls, passageways, stairs, etc., which seems reasonable.



FIG. 75

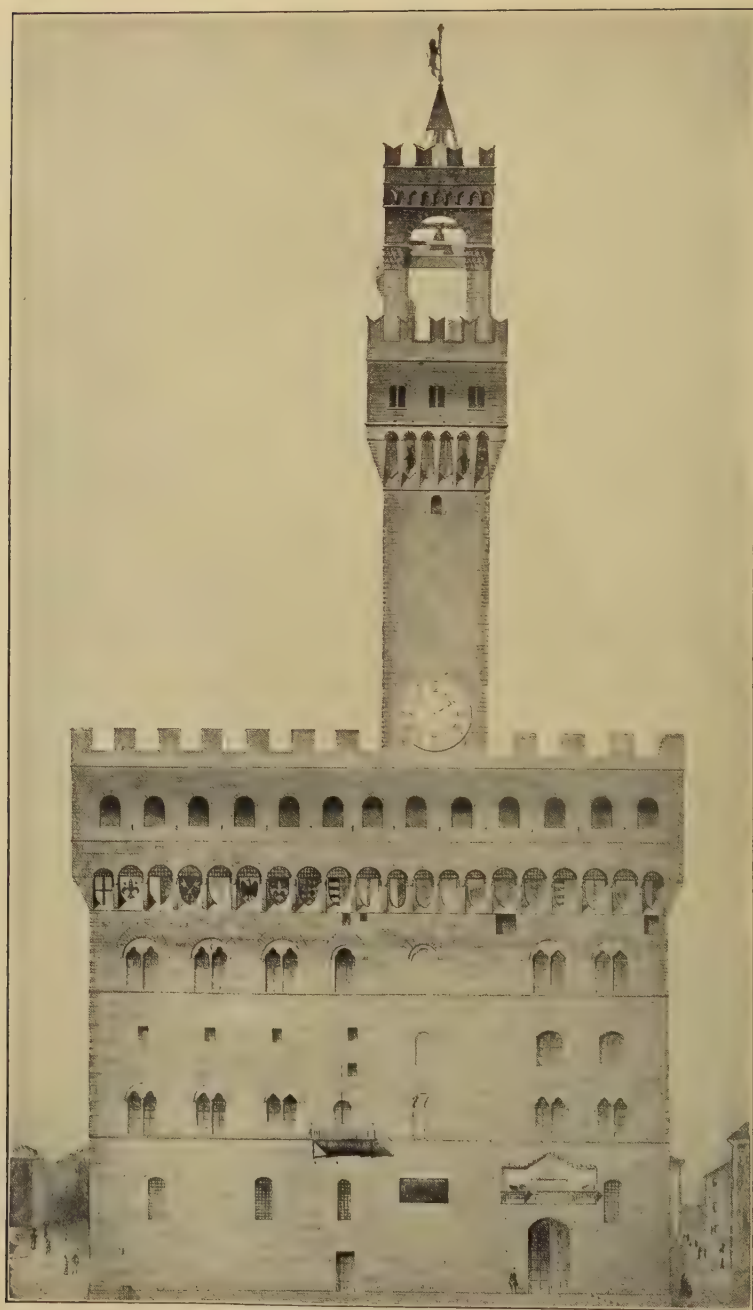


FIG. 76

WASH DRAWINGS

133. In order to become familiar with the effect of wash work in plain elevations, it is well to make studies of existing façades, either from written descriptions, as suggested in Art. 124, or from measured sketches, as described in Art. 122. The latter method is far preferable, as it gives practice in architectural surveying, drawing, and rendering.

In the large foreign and American architectural schools, the students that attain a high average in their studies are awarded traveling scholarships that give them opportunity for this line of study. The traveling scholar spends a year or more studying the historic buildings of Europe, and making measured drawings of them. These are preserved for future reference and serve to show what use he has made of his time.

134. In Fig. 75 is shown an elevation of St. Mark's Library, in Venice. This design was made from measured drawings and rendered in wash by a student of the National French Architectural School. The student in this case has undoubtedly measured every minute detail, in order that there could be no error, and every piece of carved work is as accurately rendered in the drawing as it was executed in the structure itself. The amount of time required for the completion of a study like this is very great; but at the same time it is of little importance when compared with the immense value of the experience attained in searching so carefully into the minute details of a recognized design of merit and reproducing them on the spot.

135. Another study by a traveling scholar is shown in Fig. 76. This design was made by an American student, and is a measured drawing of the front elevation of the Palazzo Vecchio at Florence. While made with no less care and drawn with equal accuracy, this drawing does not appear so much like a mechanical reproduction as does that of the French student. The study in Fig. 76 pronounces itself plainly as a wash drawing of a building façade, show-

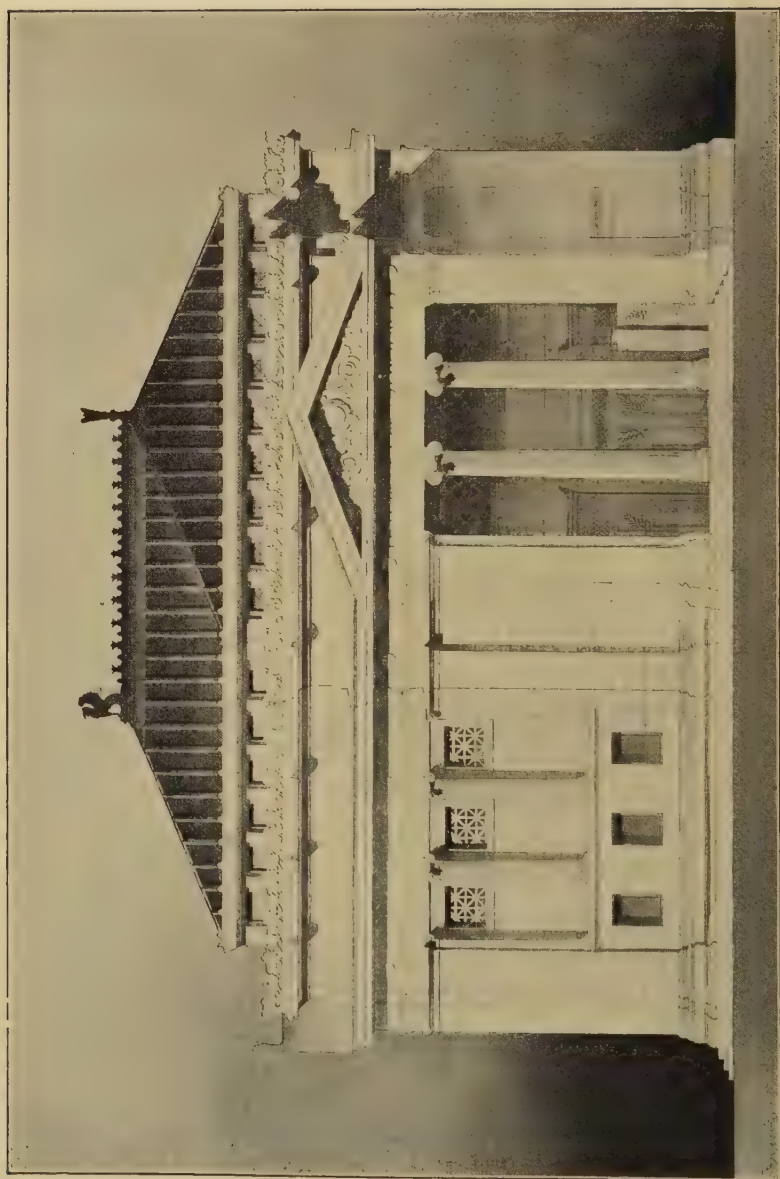


FIG. 77

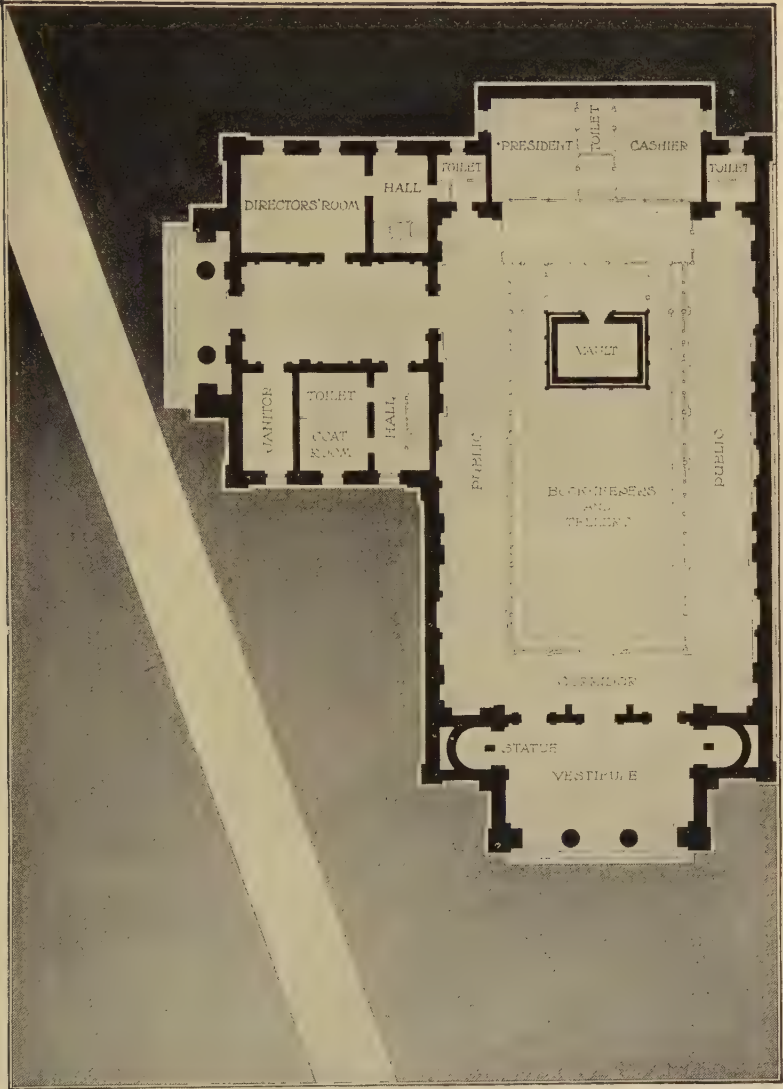


FIG. 78

ing every detail clearly; that in Fig. 75 avoids the informality of a wash drawing, and assumes the accuracy and monotony of a photograph. This difference in handling characterizes more or less the American and foreign schools of architectural rendering.

136. In Fig. 77 is shown the front elevation of the bank problem drawn out to scale and worked up in wash. Architectural drawings are not worked up to such an elaborate extent, except where the importance of the building requires that a pictorial rendering shall be made in order that the general effect of the grouping can be studied.

In cases where drawings are submitted in competition, so that the best set of plans may be selected from several submitted designs for a proposed building, it is desirable to work up the designs so that the drawings will make the best possible impression. Plans, too, are worked up in wash effect for such purposes, and the bank plan, Fig. 78, is an example of how the pictorial value of a simple architectural sketch, such as shown in Fig. 72, can be worked up to suggest the most painstaking efforts to qualify to conditions.

PRACTICAL PLANNING

PROPORTIONING OF ROOMS

137. The practical side of laying out the rooms of a house, the offices of a commercial building, or the apartments of any structure consists in designing the plan to its place and purpose. The location of the property on which the building is to be erected will determine to a certain extent the shape and proportions of the building, whereas the purpose to which it is to be put will influence the arrangement and sizes of the rooms. The question of cost will affect its elaboration, but this need not in any way affect its convenience or suitability to its purpose, as it is the architect's duty to work out all the complex details of such a problem within the proposed expenditure and to report promptly the impos-

sibility of such a proceeding if he finds that the appropriation is insufficient.

The well-planned house is perfectly adapted to the needs of the family for which it is built, and can hardly suit any other family quite so well, because the better it is suited to one individual, or one set of individuals, the less it will be suited to some other.

138. Dining Room.—While the number of persons in a family will determine the number of rooms in the house, they will also determine to a great extent the size of the principal rooms. The dining room is the one room of the whole house in which the entire family will be assembled at one time most frequently, and a well-determined idea as to the size of this room is necessary at the outset. A large and expensive house will naturally suggest a monumental, elaborate dining room, whereas a small, economical house will suggest a less elaborate treatment.

Assume the dining table to be $4\frac{1}{2}$ feet in diameter. Large tables are as wide as 6 feet, but these can be used only in very large rooms. A person seated at a table requires 16 inches from the edge of the table to the back of the chair, and 20 inches where a large armchair is used. A width of 2 feet 4 inches is a moderate allowance for a person at the table, and in determining the size of a table required to seat a given number, 2 feet 4 inches should be multiplied by one less than half the number of people to be seated. The amount of space required for the table and the persons to be seated around it will be from 32 to 40 inches more in each direction than the space occupied by the table itself. A passageway of from 2 feet 6 inches to 3 feet 6 inches is also required behind the backs of the chairs, which, on both sides of the room, makes from 5 to 7 feet more. With the $4\frac{1}{2}$ -foot dining table, this gives a minimum width of the room of about 12 feet, but it makes no provision for furniture against the walls; therefore, this furniture should also be taken into consideration. A buffet, serving table, or china closet must nearly always be provided for.

Generally speaking, 15 feet is about as narrow as the dining room should be made. The length of the room depends entirely on the length of the table when used to its fullest capacity, 20 feet in length making a good proportion with the width just given. A reduction of these dimensions is a step toward economy but a sacrifice of convenience. It should be borne in mind that a house planned with roomy, well-lighted dining apartments adds materially to the cheer and comfort of the occupants.

139. The room should be lighted from two sides if convenient, so that the light may penetrate each corner; but if it can be illuminated from only one side or the end, the windows should be spread apart in order to diffuse the light as much as possible, as otherwise objects will cast strong shadows and numerous dark corners will result. Where the light is from the end of the room, it shines into the eyes of not more than one person seated at the table, whereas if it is from the side of the room, all persons sitting at one side of the table will be subject to the glare.

The dining room should never face the west, because the setting sun will shine directly in the room at the hour of the evening meal and in the morning, particularly in winter, the room will be dark and cheerless. When the windows open to the east or the southeast, the first rays of the rising sun will make the room cheerful on the winter morning, and at the hour of the evening meal in summer, the sun will pass around sufficiently to leave the room cool and inviting.

140. Pantry.—The dining room should communicate with the kitchen directly through the pantry, or if on another floor, by means of a dumb waiter. The dumb waiter should never open directly into the dining room, but into the pantry at the side of the dining room, as the noises from the kitchen will ascend the dumb-waiter shaft and annoy the diners. Where communication is had with the kitchen through the pantry, the doors should be arranged so that no person can see through the pantry into the kitchen even when both doors are open. The pantry should contain a sink, a table,

and closets for china and linen. The closet for the dishes may have either swinging doors or sliding doors, the latter being preferable, as they take up less room. The sink in the pantry should be of porcelain or enameled iron, and in it all the fine china from the dining room is washed and then drained on a wooden drip board located at one end or at both ends.

141. Drawing Room.—The drawing room, or parlor, should be conveniently near the dining room, although not necessarily connected with it. In small houses of an unpretentious character, the two rooms can be advantageously connected by means of sliding doors or an open archway screened with curtains; but in larger and more pretentious residences, it may be of advantage to have the parlor separated entirely from the dining room.

The distinction between the terms drawing room and parlor is a simple one, although according to custom, the latter term usually refers to a less formal apartment. The term *drawing room* is derived from the late feudal times when an apartment was cut off from the great hall and termed a *withdrawing room*. The term *parlor* is of French origin, and means a conversation room, from *parler*, to speak. In either case, the derived meaning is the same.

The size of the parlor depends of course on the character of the house and the number of persons that are likely to occupy it at one time. An oblong room admits of a better decorative treatment.

In grouping the parlor windows, liberal wall space should be maintained, as this is the room where formal pictures are hung. The windows of the parlor should also be arranged so far as possible to command the finest view. The entrance doors should be wide and liberal, otherwise the interior will have a box-like appearance. If there is to be a music room, a library, and a morning room in the house, it will probably be advantageous to have these rooms connect directly with the parlor or be near it, in order that all may be thrown together for the purpose of entertaining. Where there is only a library to connect, it may be shut off by means of a

pair of folding doors, over which portières should always be hung on the parlor side, for the double purpose of deadening the noise of conversation and of relieving the parlor of the unhospitable aspect of two tightly closed doors.

142. Library.—Every house should have a room set apart to the use of books. In some cases it is the study room for the school children, or it may be a reading room for the adults or a study for the professional man. Movable bookcases are sometimes provided, and in other cases they are built in. The shelves in either kind should be adjustable, so that they may be raised or lowered to suit the sizes of books. The top shelves should not be more than 7 feet from the floor, except where the number of books is great, under which condition the shelves may extend to the ceiling.

Windows should be considered so that all the book shelves receive ample light, the direction of that light depending entirely on the use to which the room is put. For a study that is to be occupied a large part of the time, a north light is satisfactory, owing to its evenness and freedom from sunshine. The position of the library on the plan, however, depends entirely on its purpose, in some cases being a private room and in other cases, a family room requiring publicity.

143. Billiard Room.—A billiard room is governed in its proportions by the size of the table it is to contain. The regulation billiard table measures 5 ft. $\times$ 10 ft., although a smaller size, 4½ ft. $\times$ 9 ft., is frequently used in residences. There must be a space of at least 5 feet between the edge of the table and the wall, but 7 feet at the sides and 6 feet at the ends would make a better proportion for the room. Therefore, 15 ft. $\times$ 20 ft. is as small a room as can be conveniently used for a billiard table, and this dimension does not admit of any provision for spectators that would materially interfere with the game if they were permitted to encroach on the 5-foot limit. Where possible, a platform 3 feet wide should be provided, either in the recess of a bay window attached to the room, or against one wall at the side

or end of the room, which must be extended 3 feet to provide for it.

The lighting of this room is of vast importance. Where it can be built in an extension one story high, a skylight affords the best means of illumination. Where an extension cannot be provided, the room can be arranged for in the second story, or even in the third story, in order to bring it under a roof, otherwise it will have to be illuminated by windows high up in the sides of the room so that the shadows cast by the balls will fall beneath them.

144. Music Room.—The music room may be anything from a small apartment set aside for instruction and practice to a large room for the entertainment of guests. Its shape is of little importance, but it should connect through a wide opening with some other room if its dimensions are small. The square grand piano is 7 ft. $\times$ 3 ft. 6 in., whereas the upright piano is 5 ft. $\times$ 2 ft. 6 in. These dimensions should be taken into consideration in laying out a small room exclusively for piano accommodation. In a large music room, the floor should always be of hardwood, over which rugs may be laid, except during entertaining at a formal concert, when the floor should be bare on account of acoustic properties.

145. Kitchen.—The kitchen is in many respects the most important factor in the domestic economy of the establishment. The range must be placed where it will receive the best light, have plenty of working space around it, and be convenient to the sink, work table, and dresser. If the range in the kitchen can be lighted from two opposite sides, it makes a very desirable arrangement, producing excellent ventilation during warm weather and preventing dark corners.

The store room opening out of the kitchen should have a window of its own, preferably toward the north, so that the sun cannot shine in and make it unduly warm in summer.

A great mistake of some architects is to leave the planning of the location of the kitchen until the rest of the details of the house has been settled, whereas the first consideration

should be given to the location of the kitchen and the dining room. The kitchen should be in the north or northeast corner of the plan if possible, with at least one of its windows opening in a direction that will admit the sunshine. It should never be placed in the northwest corner of the house, as it will invariably be hot during the summer afternoons.

The laundry should always be separated from the kitchen, and although laundry work is performed only once a week, there should be a separate room for this purpose, so as not to interfere with other household duties.

146. Bedrooms.—Another mistake is frequently made in the designing of bedrooms. The first consideration should be a suitable location for the bed, which should be placed beyond the line of all possible drafts and at the same time in a position where it cannot be seen from the hall when the door is half open. A double bed is 6 feet 6 inches long and 4 feet 6 inches wide; a single bed is 2 feet 8 inches wide and 6 feet 4 inches long. A bed should be placed with its head to the wall, and both sides should be open and free, so that it may be easily made up. A bureau is 4 feet 6 inches long and 2 feet wide, and it should usually be placed between two windows.

The location of bedrooms should be given careful study, as there is a great choice of positions on the plan. There are generally at least two rooms on the second floor that open into each other, with a dressing room between, and this is located near the top of the main stairs. Where there is to be a nursery, it should be near these family rooms, as should also the bathroom. The guest rooms should be near and in plain sight of the staircase.

147. Bathroom.—In designing the bathroom, it is best to be liberal and have it too large rather than too small. The bathroom is not a luxury, but a modern necessity, and it must be so placed that it will give a direct line for waste pipes and protect them from exposure in cold weather. This room should also be convenient to the principal bedrooms, and should be near the top landing of the main stairs. The

supply and waste pipes must run in a direct line from the second-story fixtures to the cellar. The bathroom should be well lighted and should have a sunny exposure. Where possible, the walls and floors should be of tile. Bathtubs are from 5 feet to 6 feet 6 inches in length and 3 feet 3 inches in width. Slabs for wash basins vary in size, but the smallest convenient size for a 14-inch basin is 21 inches in width and 24 inches in length. All these should be drawn to scale on plans, so as to observe carefully their general effect.

METHODS OF PLANNING

148. In designing a building, the first detail that usually receives the architect's attention is the plan. This is due to the fact that the problem generally demands a certain fixed arrangement of certain rooms of a certain size and proper corridors and passages to reach them. For this reason, the plan is frequently considered as the detail of most importance in the solution of the architectural problem. This method is wrong and is likely to lead to serious difficulty with the interior and exterior details if those details are left out of consideration until after the plan is complete. The plan is a mere incident in the whole design, and must not absorb all the attention while studying the problem. Every detail of the plan must be carefully considered as a possibility in the resulting whole as it is worked in place. The arrangement of the apartments to suit the future occupants of the building must be accomplished with a full regard for the effect that arrangement will have on the general effect of the whole.

In working out the plan of the building, the architect should consider it simply as a horizontal section of the whole structure he has pictured in his mind. Thus, the resulting elevations will work out themselves and there need be no cutting and fitting afterwards to make one fit the other, as is often the case.

The successful design can be reached only when the plans, elevations, and sections are carried along at one time. The

preliminary sketches are worked out for the sake of the masses, the grouping and effect of these masses being studied at one time in all drawings. Then preliminary block plans can be worked, introducing the more important details, and, finally, the full-scale working drawing, all started with the full knowledge that the masses and minor details will fall into their proper places without forcing or changing.

149. In studying these preliminary plans and sketches, there is only one method of attaining the best results, and that is by tracing and retracing every part of the design and studying the effect of these traced parts in combination with every new detail or proposed detail.

In studying out the plan, it should be borne in mind that it is more than a mere diagram of the convenience of arrangement of the rooms. In it are expressed many of the artistic details of the decorative treatment of the entire interior. The sizes of the rooms will determine the height of the ceilings, and as some large rooms may demand an appearance of greater loftiness than can be conveniently provided for, the immediate suggestion is to introduce a pilaster treatment in the side wall. These pilasters must be indicated in the plan, as they will influence the spacing of the doors and windows. But, again, these doors and windows may affect the treatment of the exterior wall, and the elevations must also be considered when the plan is worked out.

The proportioning of the rooms as to their length and breadth is also a detail of esthetic importance, and will determine to some extent the location of the partitions and subdivisions in the second story. Therefore, the second-story plan, and consequently its elevations, must be worked out at the same time as the rest of the structure.

150. In planning a series of rooms, they should always be laid out on axial lines, and the leading architectural features of the plan should be located on these lines, so as to provide a symmetrical arrangement. *Symmetry* is a most desirable characteristic of a plan of a building, and is best attained

through simplicity. Complicated and irregular plans are evidence of carelessness or inability, whereas satisfactory results attained in the simplest manner are evidence of ingenuity. The highest art and skill are required to satisfy all the complicated demands of an important building in a plan, the drawing of which seems to have been carried out on the simplest possible lines, all parts fitting exactly into place without force or makeshift. By studying the plans of the great Greek temples, the Renaissance palaces, and the Gothic cathedrals it will be possible to observe the simple manner in which all the varied and complex parts are united into a harmonious whole.

151. Symmetry in architectural design does not necessarily mean duplication of parts on opposite sides of an axial line. It is simply a detail in composition requiring that principal parts of equal importance shall receive equal attention in their design and arrangement. The four sides of the Parthenon are symmetrical, and consequently the building is conspicuous for its simplicity.

A treatment somewhat akin to symmetry is *balance*, where two objects of equal importance are introduced into the plan on opposite sides of an axial line to balance each other, although they may in no way be symmetrical. For instance, a fountain in one recess in a monumental hallway might be balanced by a group of statuary in an opposite recess.

Where neither symmetry nor balance can be attained, the other extreme should be attempted; that is, an endeavor should be made to design the opposing details as unlike as possible. In this way, it will be possible to arrive at results that have no feeling of cramped or forced work, and the plan becomes monumental in effect.

152. A *monumental plan* is one that produces a feeling of vastness, without restriction in any part. Simplicity of arrangement, symmetry of design, and balance of principal details combine to produce this monumental effect. The approaches, entrance stairway, and halls are the first part of a building that meets the public eye, and as first impressions

count for much, these details should be dealt with in a monumental manner.

On entering the French and English cathedrals, a decidedly different impression is gained, owing entirely to the liberal openings of the French edifices as compared with the cramped doorways that admit the public to the English structures.

These are considerations that apply in their way just as much to the private residence as to the public hall. Even in country houses, the entrance hall constitutes a large rectangular room with an imposing stairway, instead of the narrow tunnel-like passage, half choked by a narrower stairway, that characterized the American residences of half a century ago.

EXERCISE IV

Prepare a design for the plan and one elevation for *one* of the following buildings. The drawing is to be neatly rendered in wash or color and rooms and other details properly lettered.

(a) A small museum for a corner lot 75 ft. $\times$ 100 ft., to contain four separate rooms for the exhibits, besides a curator's office, public coat room, toilet rooms, etc.

(b) A small library on a corner lot 75 ft. $\times$ 100 ft., to contain a stack room, two reading rooms, a reference room, an office for the librarian, a retiring room for his assistants, and a public lavatory.

(c) A small art gallery on a lot 50 ft. $\times$ 100 ft., to contain a room for paintings, a room for sculpture, a public coat room, offices for the custodian and curator, and a public lavatory.

These designs are to be drawn to any convenient scale that will show the details, and are to be finished and rendered similarly to the bank problem in Figs. 77 and 78.

INDEX

NOTE.—In this volume, each Section is complete in itself and has a number. This number is printed at the top of every page of the Section in the headline opposite the page number, and to distinguish the Section number from the page number, the Section number is preceded by a section mark (§). In order to find a reference, glance along the inside edges of the headlines until the desired Section number is found, then along the page numbers of that Section until the desired page is found. Thus, to find the reference "Anchors, §7, p55," turn to the Section marked §7, then to page 55 of that Section.

A

Absorption, Tests of, §37, p11
 Acme plaster, §38, p26
 Adamant plaster, §28, p26
 Agatite plaster, §38, p26
 Alternation, Definition of, §52, p14
 American bond, §7, p37
 or common, bond, §11, p39
 Amount of mortar required, §11, p31
 Analyzing of existing designs, §52, p123
 Anchoring terra cotta, §12, p69
 Anchors, §7, p55
 for terra cotta, §12, p27
 Angles, Bonding walls at, §7, p43
 Ankyra anchor bolts, §13, p55
 Apartments, Hollow-tile, §13, p67
 Appliances, Illuminating, §42, p3
 Application of architectural principles, §52, p123
 Arch brick, §7, p5
 ring, Meaning of, §7, p48
 Arched openings, §13, p50
 Arches, §7, p47
 Brick, §7, p47
 Construction of, §7, p49
 Relieving, §7, p46
 Rowlock, §7, p46
 Architectural design, Definition of, §52, p1
 proportion, §52, p32
 terra cotta, §12, p1
 Architecture, Composition in, §52, p13
 Architraves, Kinds of, §52, p88
 Art glass, §42, p41
 glass, Color and finish of, §42, p42
 glass for shades, Making, §42, p41
 glass, Shaping, §42, p41
 Artificial marble, §38, p32

Ash doors, §7, p70
 -pits, §7, p70
 Assembling of lighting fixtures, §42, pp67, 71
 Auxiliary masses, §52, p26
 Ax, Tooth, §37, p13

B

Back brick, §7, p5
 Backing, Meaning of, §11, p5
 -up brickwork, §7, p53
 Backup tile, §13, pp23, 48
 Balustrades, Terra-cotta, §12, p63
 Banded columns, Terra-cotta, §12, p58
 Bands, §11, p47
 Bank building, Problem in design of a, §52, p133
 Base for plastering, Grille, §38, p2
 for plastering, Lithic, or stone, §38, p2
 Bases, Capitals and, §52, p90
 Bathroom, Location of, §52, p152
 Bats in brickwork, §7, p34
 Bedrooms, Location of, §52, p152
 Bending and brazing, §42, p65
 Billiard room, Location of, §52, p150
 Blind joint, Meaning of, §11, p6
 Blocks, Silo, §13, p24
 Blue shale, §13, p5
 Bluestone, §37, p5
 Boards, Plaster, §38, p10
 Bolts, Ankyra anchor, §13, p55
 Bond, American, or common, §7, p37; §11, p39
 Dutch, §11, p39
 English, §7, p35; §11, p38
 Face, §7, p40; §11, p36

- Bond, Flemish, §7, p37; §11, p37
 in brickwork, §7, p33; §11, p36
 Meaning of, §11, p5
 Running, §11, p37
 Stretcher, or running, §7, p4
 Bonding face brick, §7, p40
 hollow walls, §7, p42
 Terms used in, §7, p34
 tile, §13, p20
 walls at angles, §7, p43
 with metal ties, §7, p43
 Bonds, Miscellaneous, §11, p39
 Standard, §7, p35
 Borders, §11, p51
 in brickwork, §11, p51
 Bostwick metal lath, §38, p9
 Box, Mixing, §38, p13
 -shaped hollow tile, §13, p5
 Bracket lantern, Combination, §42, p24
 lantern, Hanging, §42, p25
 lanterns, §42, p24
 Two-light, §42, p5
 Two-light combination, §42, p11
 Brackets, §42, p4
 Combination column, §42, p16
 Double-swing, §42, p7
 Electric column, §42, p13
 for gas, Stiff, §42, p4
 for one electric light, §42, p7
 for two or more electric lights, §42, p9
 Gas column, §42, p13
 Movable, or swing, §42, p7
 One-light combination, §42, p10
 Brazing and bending, §42, p65
 Breaking joints, §7, p34
 joints, Meaning of, §11, p6
 Brick, §7, p1
 Arch, §7, p5
 arches, §7, p47
 Back, §7, p5
 Classification of, §7, p4
 Clinker, §7, p5; §11, p20
 Color of, §7, p8
 colors, §11, p22
 colors, Causes and varieties of, §11, p22
 Common, §7, p4
 Definition and description of, §7, p1
 Definitions of parts of, §11, p4
 Dressed, §7, p4
 Drying and burning of, §7, p4
 End-cut, §11, p20
 Face, §7, pp4, 5
 field, Meaning of, §11, p6
 Fire-flashed, §7, p6
 fireplaces, §11, p60
 Front, §7, p5
 Hard, §7, p5
 Brick, Hollow, §7, p6
 Ingredients of, §7, p2
 in severe weather, Laying, §7, p20
 Interior walls of, §11, p55
 Kiln-run, §7, p5
 Manufacture of, §7, p2
 Medium, §7, p5
 Molded, §11, p24
 Paving, §7, p6
 Pressed, §7, pp4, 6
 Red, §7, p5
 Rough-hard, §7, p5
 Salmon, §7, p5
 Sand or sand-lime, §7, p6
 shapes and sizes, §11, p15
 Side-cut, §11, p20
 Soft, §7, p5
 Straight-hard, §7, p5
 Stretcher, §7, p5
 textures, §11, p19
 Vitrified, §7, p5
 walls, §7, p25
 walls, Types of, §7, p25
 Well-burned, §7, p5
 Wire-cut, §11, p19
 Bricklaying, §7, p12
 Tools used in, §7, p12
 Bricks, Gauged, §7, p49
 Hand-made, §7, p2
 Machine-made, §7, p3
 Molded, §7, p4
 Quality of, §7, p7
 Sanded, §7, p2
 Shaped, §7, p49
 Size of, §7, p7
 Slop, §7, p2
 Water-struck, §7, p2
 Weight of, §7, p7
 Wood, §7, p60
 Brickwork, §7, p8
 Backing-up, §7, p53
 Bond in, §7, p33
 Borders in, §11, p51
 Chain-pattern in, §11, p47
 Common, §7, p1
 Definitions of parts of, §11, p4
 Efflorescence on, §7, p53
 Face, §11, p15
 in America, History of, §11, p14
 in ancient Rome, History of, §11, p7
 in Egypt, History of, §11, p6
 in England, History of, §11, p11
 in France, History of, §11, p14
 in Italy, History of, §11, p9
 in Netherlands, History of, §11, p11
 in Persia, History of, §11, p9
 Labor required for, §7, p12

Brickwork, Measurement of, §7, p10*
 Metal ties for, §7, p41
 Ornamental, §11, p60
 Panels in, §11, p51
 Strength of, §7, p9
 Broached work, §37, p24
 Bronze standard, §42, p48
 Brown, or floated, coat of plaster, §33, p22
 Brushes, Comb and, §38, p16
 Building, Measuring up a, §52, p128
 Methods of planning a, §52, p153
 Problem in design of a bank, §52, p133
 stone, Varieties and qualities of, §37, p1
 Burning of brick, Drying and, §7, p4
 Burnishing, Plating and, §42, p69
 Bush hammer, §37, p14
 -hammered work, §37, p25

C

Candelabra, §42, p47
 Construction of, §42, p47
 Candles for lighting purposes, §42, p2
 Candlesticks, Electric, §42, p53
 Gas, §42, p52
 Capitals and bases, §52, p90
 Caps, Chimney, §7, p64
 Carton pierre, §38, p31
 Cartouches, Terra-cotta, §12, p61
 Carved wooden ceiling lights, §42, p44
 work, §37, p29
 Cast-metal standards, §42, p49
 Casting, §42, p62
 Castings, Cleaning of, §42, p64
 Ceiling lights, §42, p42
 lights, Carved wooden, §42, p44
 lights, Crystal, §42, p47
 lights, Examples of, §42, p43
 Cement, §11, p29
 Keene's, §38, p27
 plasters, Natural, §38, p26
 Portland, §11, p29
 White Portland, §11, p29
 Centering, §13, p58
 Centerpieces, Plaster, §38, p30
 Chain pattern in brickwork, §11, p47
 Chandelier details, §42, p30
 Chandeliers, §42, p25
 Combination, §42, p29
 Construction of, §42, p26
 Electric, §42, 27
 Gas, §42, p27
 Chases, §7, p51; §13, pp18, 45
 in hollow tile walls, §13, p37
 Chasing of lighting fixtures, §42, p67
 Chemical, or patent, plasters, §38, p26
 Chimney caps, §7, p64

Chimney pots, §7, p65
 Chimneys, §7, p60
 Construction of, §7, p60
 Design of, §7, p60
 Chisels, §37, p14
 Classic proportions in architectural orders, §52, p46
 Classification of brick, §7, p4
 Clay used in terra cotta, §12, p30
 Cleats, §13, p60
 Clinker brick, §7, p5; §11, p20
 Clinkers, §7, p5
 Clinton stiffened laths, §38, p7
 Closers and bats, Meaning of, §7, p34
 Coarse stuff, Use of, §38, p18
 Coating terra cotta, §12, p33
 Cocks and fittings, §42, p55
 Color and finish of art glass, §42, p42
 in stucco, §13, p65
 of brick, §7, p8
 Coloring materials for mortar, §11, p29
 terra cotta, §12, p14
 Colors, Brick, §11, p22
 Columns, §13, p51
 Terra-cotta, §12, p55
 Comb and brushes, §38, p16
 Combination bracket lantern, §42, p24
 chandeliers, §42, p29
 column brackets, §42, p16
 dining-room fixtures, §42, p36
 end fitting, §42, p57
 floor, §13, p57
 lanterns, §42, p23
 lights, §42, p51
 pendants, §42, p17
 reflector pendants, §42, p20
 Common bond, §7, p37; §11, p39
 brick, §7, p4
 brickwork, §7, p1
 Compactness, Tests of, §37, p11
 Composite order, §52, p73
 order, Table of the, §52, p76
 Composition, Design and, in architecture, §52, p3
 in architecture, §52, p13
 in architecture, Elements of, §52, p10
 Concrete walls, Terra-cotta facings on, §12, p45
 Construction of lighting fixtures, §42, p59
 Continuity, Repetition and, in architectural design, §52, p13
 Contrast, Definition of, §52, p15
 Corinthian order, §52, p69
 order, Table of the, §52, p72
 Corner blocks, §13, p23
 blocks, Hollow-tile, §13, p38
 tile, §13, p19

Cornice and molding templets, §38, p16
 Cornices, §52, p87
 and string-courses, Styles of, §52, p120
 Molding of plaster, §38, p28
 Terra-cotta, §12, p47
 Course in brickwork, §7, p34
 Crown, Meaning of, §7, p48
 Crandall, The, §37, p14
 Crandalled work, §37, p24
 Cross-furring, §38, p3
 Crown, Meaning of, §7, p48
 Crushing strength of stone, Table of, §37, p7
 Crystal ceiling lights, §42, p47
 Culls, §7, p4
 Curtain walls, §7, p28

D

Dampers, §7, p69
 Damp-proofing brick walls, §7, p26
 Dash, Description of, §38, p34
 Degrees, Lines at 45, §52, p78
 Lines at 60, §52, p81
 Dense hollow tile, §13, p4
 -tile foundations, §13, p31
 Density of hollow tile, §13, p3
 Denticulated Doric, §52, p56
 Derby, §38, p16
 Design and composition in architecture, §52, p3
 Definition of architectural, §52, p1
 Elements of, §52, p3
 of a bank building, Problem in, §52, p133
 Problems in, §52, p133
 Designing terra cotta, §12, p15
 Designs, Analyzing of existing, §52, p123
 Surface, §52, p3
 Various, §42, p37
 Details, Grouping of minor, §52, p13
 Grouping of more than three, §52, p43
 Grouping of principal, §52, p39
 Grouping of three, §52, p42
 Grouping of two, §52, p41
 Dining-room and library fixtures, §42, p34
 -room fixtures, Combination, §42, p36
 room, Location of, §52, p147
 Dipping and polishing of lighting fixtures, §42, p68
 Dissimilar masses, Grouping of, §52, p23
 Domes and shades, §42, p40
 Terra-cotta, §12, p64
 Doric, Denticulated, §52, p56
 Greek, order, §52, p96
 intercolumniations, §52, p115
 Mutual, §52, p56
 order, §52, p54
 order, Table of the, §52, p60

Double-face hammer, §37, p12
 -swing brackets, §42, p7
 walls, §7, p26
 Drawing, §52, p85
 room, Location of, §52, p149
 Drawings, Wash, §52, p143
 Dressed brick, §7, p4
 Drips in terra cotta, §12, p44
 Drove work, §37, p24
 Drums, Terra-cotta, §12, p55
 Dry-clay process, §7, p3
 Drying and burning of brick, §7, p4
 Durability of building stone, Table of, §37, p8
 Dutch bond, §11, p39
 bond, Variations of, §11, p41
 Dwelling houses, §52, p138
 Dwellings, Hollow-tile, §13, p67

E

Efflorescence, §7, p53
 Electric candlesticks, §42, p53
 chandeliers, §42, p27
 column brackets, §42, p13
 fixtures, Gas and, §42, p3
 lanterns, §42, p22
 light, Brackets for one, §42, p7
 lights, Brackets for two or more, §42, p9
 pendants, §42, p17
 Electricity, Gas and, for lighting purposes, §42, p3
 Electroplating, §42, p69
 Elements of composition, §52, p10
 of design, §52, p3
 Enclosure walls, §7, p27
 End-cut brick, §11, p20
 English bond, §7, p35; §11, p38
 bond, Variations of, §11, p41
 Expanded-metal laths, §38, p8
 Exterior walls of hollow tile, §13, p33
 Extrados, Meaning of, §7, p48

F

Face and ornamental brickwork, Combinations of, §11, p1
 bond, §7, p40; §11, p36
 brick, §7, pp4, 5
 brickwork, §11, p15
 Facings for walls, Terra-cotta, §12, p2
 Factories, Hollow-tile, §13, p75
 Fiber, hair and, Use of, in plaster, §38, p12
 Fine stuff, Character of, §38, p19
 Finish of joints, §11, p32
 Finishes and colors of terra cotta, §12, p32
 for stucco, §13, p65
 Finishing coat of plaster, §38, p24

- Finishing coat of stucco, §13, p65
 - Stone cutting and, §37, p12
 - Firebrick, §7, p6
 - Fire-cuts on beams, §7, p57
 - flushed brick, §7, p6
 - Fireplaces, §7, p66; §11, p60
 - Finish of, §7, p68
 - Fireproof floors, Hollow-tile, §13, p57
 - Fire-stops, §7, p52
 - walls, §7, p27
 - Fitting, Combination end, §42, p57
 - terra cotta, §12, p68
 - terra-cotta blocks, §12, p35
 - Fittings, §42, p65
 - Fixture terms, §42, p4
 - Fixtures, Assembling of, §42, p71
 - Brick, §11, p19
 - Combination dining-room, §42, p36
 - Construction of lighting, §42, p59
 - Dining-room and library, §42, p34
 - Gas and electric, §42, p3
 - Hammered-iron, §42, p45
 - Lantern, §42, p46
 - Making up lighting, §42, p64
 - Method of manufacturing, §42, p59
 - Toilet lighting, §42, p32
 - Flemish bond, §7, p37; §11, p37
 - bond, Variations of, §11, p41
 - Float, Hand, §38, p16
 - Floated, coat of plaster, Brown, or, §38, p22
 - Floor beams on hollow tile, Supports for, §13, p38
 - beams to regular tile, Anchoring, §13, p40
 - Combination, §13, p57
 - Johnson, §13, p59
 - systems, §13, p57
 - Floors, Concentrated supports for, §13, p41
 - Hollow-tile fireproof, §13, p57
 - Non-fireproof, §13, p57
 - on hollow tile, Supporting fireproof, §13, p40
 - on H tile, Supporting, §13, p44
 - Flue lining, Size of, §7, p62
 - Flues, §7, pp51, 61
 - Sizes of, §7, p62
 - to fireplaces, Proportions of, §7, p63
 - Foundations of dense tile, §13, p31
 - of hollow tile, §13, p31
 - of telephone-conduit tile, §13, p32
 - Four or more masses, Group of, §52, p22
 - Friezes and bands, §11, p47
 - Fringing for lighting fixtures, §42, p41
 - Front brick, §7, p5
 - Furring, §7, p59
 - Cross-, §38, p3
 - Definition of, §38, p3
 - Metal, §38, p7
 - Furring strips, §7, p26
 - to walls, Attaching, §13, p53
- G**
- Gable walls, Finishing, §13, p45
 - Gables, Hollow-tile, §13, p43
 - Gas and electric lighting fixtures, §42, p3
 - and electricity for lighting purposes, §42, p3
 - burner, Self-lighting, §42, p57
 - candlesticks, §42, p52
 - chandeliers, §42, p27
 - cock, Common, §42, p55
 - cock, Concealed, §42, p55
 - column brackets, §42, p13
 - lanterns, §42, p21
 - pendants, §42, p16
 - shields, §42, p58
 - Stiff brackets for, §42, p4
 - swing joint, §42, p55
 - table lamps, §42, p52
 - Gauge of metals, Table of thickness and, §42, p66
 - Gauged bricks, §7, p49
 - stuff, Nature of, §38, p19
 - General proportions in Vignola's orders, §52, p85
 - Geometrical relations of Vignola's orders, §52, p78
 - Glass, Art, §42, p41
 - balls, Beads and, §42, p40
 - Color and finish of art, §42, p42
 - for shades, Making art, §42, p41
 - Shaping art, §42, p41
 - Glazed hollow tile, §13, p4
 - Gneiss, §37, p2
 - Granite plaster, §38, p26
 - Granites, §37, p1
 - Greek Doric order, §52, p96
 - Ionic order, §52, p99
 - orders, §52, p96
 - Green plastering work, §38, p24
 - Grille base for plastering, §38, p2
 - Grit for mortar, §11, p28
 - Grounds, §7, p59; §13, p56
 - Spot, §13, p61
 - Group of four or more masses, §52, p22
 - of three masses, §52, p21
 - of two masses, §52, p19
 - Grouping of a simple mass, §52, p40
 - of architectural details, §52, p17
 - of dissimilar masses, §52, p23
 - of minor details, §52, p43
 - of more than three details, §52, p43
 - of principal details, §52, p39
 - of three details, §52, p42

Grouping of two details, §52, p41
Gypsum, §38, p12

H

Hair and fiber, Use of, in plastering, §38, p12
Half bat, §7, p34
Hammer, Bush, §37, p14
 Double-face, §37, p12
 Hand, §37, p14
 Patent, §37, p14
 Peen, §37, p13
Hammered-brass lights, §42, p46
 -iron fixtures, §42, p45
Hand float, §38, p16
 hammer, §37, p14
Handling terra cotta, §12, p67
Hand-made bricks, §7, p2
Hanger, Duplex, §7, p56
 Lane, §7, p56
 Van Dorn, §7, p56
Hangers, §7, p55
Hanging bracket lantern, §42, p25
Hard brick, §7, p5
 -finished white coat of plaster, §38, p25
 plasters, Advantages of, §38, p23
 plasters, Application of, §38, p27
 wall plasters, §38, p25
Haunches, Meaning of, §7, p48
Hawk, hoe, and shovel, §38, p13
Header, Meaning of, §11, p4
Headers, Meaning of, §7, p34
Herring-bone pattern in brickwork, §11, p46
History of illumination, §42, p1
Hoe, shovel, and hawk, §38, p13
Hollow brick, §7, p6
 tile, Advantages and nature of, §13, p1
 -tile apartments, §13, p67
 tile, Backup, §13, pp23, 48
 tile, Brick veneering on, §7, p28
 -tile chases, §13, p37
 tile, Chicago building laws for, §13, p29
 tile, Choice of, §13, p30
 -tile columns, §13, p51
 -tile corner blocks, §13, p38
 tile, Cutting, §13, p37
 tile, Dense, §13, p4
 tile, Density of, §13, p3
 -tile dwellings, §13, p67
 tile, Examples of buildings of, §13, p67
 -tile exterior walls, §13, p33
 -tile factories, §13, p75
 -tile fireproof floors, §13, p57
 tile, Fireproof roofs on, §13, p42
 tile, Form and use of H-shaped, §13, p20

Hollow tile, Form and use of T-shaped, §13, p15
 -tile foundations, §13, p31
 -tile gables, §13, p43
 tile, Glazed, §13, p4
 tile, H-shaped, §13, p20
 tile, Manufacture of, §13, p3
 tile, Mortar for, §13, p36
 tile, New York building laws for, §13, p30
 tile, New York laws for, §13, pp30, 35
 tile, Non-fireproof roofs on, §13, p42
 -tile office buildings, §13, p82
 -tile partitions, §13, p56
 -tile piers, §13, p53
 tile, Porous, §13, p4
 tile, Radius, §13, p51
 -tile railroad stations, §13, p82
 tile, Regular, or box-shaped, §13, p5
 tile, Scored-surface, §13, p29
 tile, Scratched-surface, §13, p28
 tile, Semiporous, §13, p4
 tile, Setting regular, §13, p10
 tile, Shapes and kinds of, §13, p5
 tile, Smooth surfaces of, §13, p28
 tile, Special shapes of, §13, p12
 tile, Special shapes of T-shaped, §13, p18
 tile, Strength of, §13, p29
 tile, Supporting fireproof floors on, §13, p40
 tile, Supports for floorbeams on, §13, p38
 tile, Surfaces of, §13, p28
 tile, T-shaped, §13, p15
 tile, Uses of, §13, p30
 tile, Vitrified, §13, p5
 tile walls, §13, p45
 -tile walls, §13, p45
 -tile walls, Veneered, §13, p45
 walls, §7, p26
 walls, Bonding, §7, p42
Holophane-shades, §42, p19
Houses, Dwelling, §52, p138
H-shaped hollow tile, §13, p20
 tile, Supporting floors on, §13, p44
 -tile walls, §13, p44
Hydrated lime, §11, p29

I

Illuminating appliances, §42, p3
Illumination and development, Primitive, §42, p1
 History of, §42, p1
Inspection and tests of stone, §37, p11
 of terra cotta, §12, p28
Intercolumniation, §52, p113
Intercolumniations, Doric, §52, p115
Interior walls of brick, §11, p55

Intrados, Meaning of, §7, p47
 Ionic, Greek, order, §52, p99
 order, §52, p60
 order, Table of the, §52, p67
 volute, §52, p82

J

Jamb blocks, §13, p13
 tile, §13, pp18, 22
 Johnson floor, §13, p59
 Joining new walls to old walls, §7, p45
 Joint, Blind, §11, p6
 Raked, §11, p33
 Rodded, §11, p33
 Rough-cut flush, §11, p33
 Struck, §11, p32
 Tooled, §11, p33
 Weathered, §11, p33
 Jointing and mitering tools, §38, p16
 Joints, Breaking, §7, p34
 Finish of, §11, p32
 in terra cotta, Concealed, §12, p43
 Meaning of breaking, §11, p6
 Mortar, §7, p9; §11, p27
 of terra cotta, §12, p39
 Pointing, §11, p36
 Rusticated, §12, p54
 Tools for finishing, §11, p34
 Tools for raking, §11, p35
 Tools used in finishing, §11, p34

K

Keene's cement, §38, p27
 Kerosene, or modern, lamp, §42, p2
 Kiln-run brick, §7, p5
 Kinds of hollow tile, §13, p5
 King closer, §7, p34
 Kitchen, Location of, §52, p151

L

Labor required for brickwork, §7, p12
 Lacquering, §42, p70
 Lamp, Kerosene, or modern, §42, p2
 Lamps, Gas table, §42, p52
 Portable table, §42, p51
 Lantern, Combination bracket, §42, p24
 fixtures, §42, p46
 Hanging bracket, §42, p25
 Lanterns, §42, p21
 Bracket, §42, p24
 Combination, §42, p23
 Electric, §42, p22
 Gas, §42, p21
 Lath, Bostwick metal, §38, p9
 Use of wooden, §13, p53

Lathing, Definition of, §38, p2
 Inspection of, §38, p36
 Laths, Clinton stiffened, §38, p7
 Expanded-metal, §38, p8
 in wood construction, Metal, §38, p9
 Metal, §38, p6
 Perforated sheet-metal, §38, p9
 Roebing, §38, p7
 Sheathing, §38, p5
 Stiffened wire, §38, p7
 Wooden, §38, p3
 Laying brick in severe weather, §7, p20
 brick, Method of, §7, p16
 trowel, §38, p13
 Library fixtures, Dining-room and, §42, p34
 Location of, §52, p150
 Light, Newel, §42, p50
 Lighting fixtures, Construction of, §42, p59
 Lights, Arrangement of, §42, p30
 Carved wooden ceiling, §42, p44
 Ceiling, §42, p42
 Combination, §42, p51
 Crystal ceiling, §42, p47
 Examples of ceiling, §42, p43
 Hammered-brass, §42, p46
 Sun, §42, p58
 Lime, §11, p29; §13, p63; §38, p11
 Hydrated, §11, p29
 putty, §11, p29
 Limestones, §37, p3
 Lines at 45 degrees, §52, p78
 at 60 degrees, §52, p81
 Vertical, §52, p82
 Lintel blocks, §13, p13
 Lintels, §13, pp18, 23
 Terra-cotta, §12, p49
 Lithic, or stone, base for plastering, §38, p2

M

Machine-made bricks, §7, p3
 tools, §37, p15
 Mallet, §37, p14
 Manufacture of brick, §7, p2
 of hollow tile, §13, p3
 of terra cotta, §12, p30
 Marble, §37, p3
 Artificial, §38, p32
 dust, §11, p29; §13, p63
 Onyx, §37, p4
 Margins, §37, p17
 Mass, Grouping of a simple, §52, p40
 Single, §52, p19
 Masses, Auxiliary, §52, p26
 Group of four or more, §52, p22
 Group of three, §52, p21
 Group of two, §52, p19
 Grouping of dissimilar, §52, p23

- Masses, Methods of proportioning, §52, p32
 Subordinate, §52, p39
 Materials for shells, §42, p67
 Plastering, §38, p11
 Proportions of plastering, §38, p17
 Measurement of brickwork, §7, p10
 Measuring up a building for making drawings, §52, p128
 Medium brick, §7, p5
 Metal furring, §38, p7
 lath, Bostwick, §38, p9
 laths, §38, p6
 laths, Expanded-, §38, p8
 laths in wood construction, §38, p9
 laths, Perforated sheet-, §38, p9
 ties, Bonding with, §7, p43
 ties for brickwork, §7, p41
 wall plugs, §13, p54
 Metals, Table of thickness and gauge of, §42, p66
 Methods of planning a building, §52, p153
 Minor details, Grouping of, in architectural design, §52, p43
 Mitering tools, Jointing and, §38, p16
 Mixing box, §38, p13
 of mortar, Machine, §38, p20
 of plastering mortar, §38, p18
 of plastering mortar, Hand, §38, p18
 Model used in casting, §42, p61
 Modeling terra cotta, §12, pp10, 28
 terra cotta in high relief, §12, p13
 Modern lamp, Kerosene, or, §42, p2
 Mold used in molding lighting fixtures, §42, p61
 Molded brick, §7, p4; §11, p24
 Molding of plaster cornices, §38, p28
 templets, Cornice and, §38, p16
 Moldings, Use of, §52, p28
 Molds for terra cotta, §12, p30
 Mortar, §7, p8; §11, p27
 Coloring materials for, §11, p29
 colors, §13, p63
 for face brick, Composition of, §11, p28
 for hollow tile, §13, p36
 Formulas for mixing, §11, p30
 for terra cotta, §12, p71
 Hand mixing of plastering, §38, p18
 joints, §7, p9; §11, p27
 joints, Effect of, §11, p27
 joints, Size of, §7, p9
 Machine mixing of, §38, p20
 Materials used for, §11, p28
 Mixing of plastering, §38, p18
 required, Amount of, §11, p31
 Suggestions for coloring, §11, p30
 Movable, or swing, brackets, §42, p7
 Mullions, Terra-cotta, §12, p52
 Music room, Location of, §52, p151
 Mutular Doric, §52, p56

N

 Nails, Self-clinching, §13, p54
 Natural-cement plasters, §38, p26
 Newel light, §42, p50
 Non-fireproof floors, §13, p57
 Numbering terra-cotta blocks, §12, p35

O

 Office buildings, Hollow-tile, §13, p82
 One-light combination brackets, §42, p10
 Onyx marble, §37, p4
 Openings, Arched, §13, p50
 in walls, §7, p45; §13, p49
 Order, Composite, §52, p73
 Corinthian, §52, p69
 Doric, §52, p54
 Ionic, §52, p60
 Table of the Composite, §52, p76
 Table of the Corinthian, §52, p72
 Table of the Doric, §52, p60
 Table of the Ionic, §52, p67
 Table of the Tuscan, §52, p54
 Tuscan, §52, p52
 Orders, Greek, §52, p96
 in classic architecture, §52, p46
 Interchanging of, §52, p124
 Vignola's, §52, p50
 Ornament, Repetition of terra-cotta, §12, p10
 Ornamental brickwork, §11, p60
 plastering, §38, p28
 work in terra cotta, §12, p3
 Ornaments, Plaster, §38, p31

P

 Packing terra cotta, §12, p67
 Panel walls, §7, p27
 Panels, §11, p51
 in brickwork, §11, p51
 Pantry, Location of, §52, p143
 Paris, Plaster of, §38, p12
 Partitions of hollow tile, §13, p56
 Party walls, §7, p27
 Patent hammer, §37, p14
 -hammered work, §37, p25
 Pattern work in brick, §11, p40
 Paving brick, §7, p6
 Pebble-dash stucco finish, §13, p67
 Pedestals, §52, p104
 Pediments, §52, p110
 Peen hammer, §37, p13
 Pendants, §42, p16
 Combination, §42, p17

- Pendants, Combination reflector, §42, p20
 - Electric, §42, p17
 - Gas, §42, p16
 - Reflector, §42, p17
 - Perforated sheet-metal laths, §38, p9
 - Pick, The, §37, p13
 - Piers, §13, p53
 - Hollow-tile, §13, p53
 - Pilasters, §52, p103
 - Terra-cotta, §12, p53
 - Pile, Sourcing, §38, p21
 - Planning of rooms of a building, Practical, §52, p146
 - Plaster, Acme, §38, p26
 - Adamant, §38, p26
 - Agatite, §38, p26
 - boards, §38, p10
 - brown, or floated, Coat of, §38, p22
 - centerpieces, §38, p30
 - composition, §42, p60
 - cornices, Molding of, §38, p28
 - Examination of walls before application of, §38, p20
 - finish, Rough-sand, §33, p25
 - Granite, §38, p26
 - Hard-finished white coat of, §38, p25
 - Names of coats of, §38, p21
 - of Paris, §38, p12
 - ornaments, §38, p31
 - Rock wall, §38, p26
 - Rockite, §38, p26
 - Royal, §38, p26
 - Scratch coat of, §38, p21
 - Straightening coat of, §38, p22
 - Troweled stucco, or skin coat, of, §38, p25
 - Windsor cement, §38, p26
 - Plasterers' putty, §38, p19
 - tools, §38, p13
 - Plastering, Description of, §38, p1
 - Finishing coat of, §38, p24
 - Grille base for, §38, p2
 - Inspection of, §38, p36
 - Lithic, or stone, base for, §38, p2
 - materials, §38, p11
 - materials, Proportions of, §38, p17
 - mortar, Hand mixing of, §38, p18
 - mortar, Mixing of, §38, p18
 - Ornamental, §38, p28
 - Preparation of walls for, §38, p2
 - Rough-cast, §38, p33
 - work, Green, §38, p24
 - work, Measurement of, §38, p37
 - Plasters, Advantages of hard, §38, p28
 - Application of hard, §38, p27
 - Chemical, or patent, §38, p26
 - Hard wall, §38, p25
 - Natural-cement, §38, p26
 - Plating and burnishing of lighting fixtures, §42, p69
 - Plugs, Metal wall, §13, p54
 - Plumb used in plastering, §38, p16
 - Pointed work, §37, p17
 - Pointing, §11, p36
 - terra cotta, §12, p72
 - Pole scaffold, §7, p23
 - Polishing, Dipping and, of lighting fixtures, §42, p68
 - Polychrome terra cotta, §12, p4
 - Porous hollow tile, §13, p4
 - Portable table lamps, §42, p51
 - Pots, Chimney, §7, p65
 - Practical planning of rooms in a building, §52, p146
 - Pressed brick, §7, pp4, 6
 - Primitive illumination and development, §42, p1
 - Principal details, Grouping of, §52, p39
 - Principles, Application of architectural, §52, p123
 - Problem in design of a bank building, §52, p133
 - Problems in design, §52, p133
 - Proportion, Architectural, §52, p32
 - Proportioning masses, Methods of, §52, p32
 - of rooms of a building, §52, p146
 - Proportions, Classic, §52, p46
 - General, §52, p85
 - of flues to fireplaces, §7, p63
 - Protecting terra cotta, §12, p71
 - Putty, Plasterers', §38, p19
- Q**
- Qualities of good stone, §37, p5
 - Quality of bricks, §7, p7
 - Quarter bat, §7, p34
 - Queen closer, §7, p34
- R**
- Radius tile, §13, p51
 - Railroad stations, Hollow-tile, §13, p82
 - Raked joint, §11, p33
 - Receiving and checking terra cotta, §12, p67
 - Red brick, §7, p5
 - Reflector pendants, §42, p17
 - pendants, Combination, §42, p20
 - Reglets in terra cotta, §12, p43
 - Regular, or box-shaped, hollow tile, §13, p5
 - Relations, Geometrical, §52, p78
 - Relieving arches, §7, p46
 - Repetition and continuity, §52, p13
 - Reveal, Meaning of, §7, p51
 - Rise, Meaning of, §7, p48
 - Rock-faced work, §37, p16

Rock wall plaster, §38, p26
 Rockite plaster, §38, p26
 Rodded joint, §11, p33
 Roebing laths, §38, p7
 Roof construction, §13, p61
 Roofs, Supporting fireproof, §13, p42
 Supporting non-fireproof, §13, p42
 Rooms in a building, Proportioning of, §52, p146
 Rough-cast plastering, §38, p33
 -cast stucco finish, §13, p67
 -cut flush joint, §11, p33
 -hard brick, §7, p5
 -sand plaster finish, §38, p25
 Rowlock, §7, p48
 arches, §7, p46
 course, Meaning of, §11, p4
 Rowlocks, §7, p46
 Royal plaster, §38, p26
 Rubbed work, §37, p24
 Running bond, §11, p37
 bond, Variations of, §11, p40
 or stretcher bond, §7, p40
 Rusticated joints, §12, p54
 work, §37, p27

S

Salmon brick, §7, p5
 Sand, §13, p62; §38, p12
 brick, §7, p6
 finish in stucco, §13, p66
 -floated stucco finish, §13, p66
 for mortar, §11, p29
 -lime brick, §7, p6
 screen, §38, p13
 Sanded bricks, §7, p2
 Sandstones, §37, p4
 Scaffold, Pole, §7, p23
 Scaffolding, §7, p21
 Exterior, §7, p21
 Inside, §7, p21
 Scaffolds, Suspended, §7, p25
 Scagliola, §38, p31
 Scale work, §37, p27
 Scored-surface hollow tile, §13, p29
 Scratch coat of plaster, §38, p21
 coat of stucco, §13, p64
 Scratched-surface hollow tile, §13, p28
 Screeds and screeding, §38, p23
 Screen, Sand, §38, p13
 Seasoning of stone, §37, p10
 Securing terra cotta to structure, §12, p44
 Self-clinching nails, §13, p54
 -lighting gas burner, §42, p57
 Semiporous hollow tile, §13, p4
 Setting regular hollow tile, §13, p10
 terra cotta, §12, p68

Shades, Domes and, §42, p40
 Holophane, §42, p19
 Making art glass for, §42, p41
 Shale used in terra cotta, §12, p30
 Shaped bricks, §7, p49
 Shapes of brick, §11, p15
 of brick, Special, §11, p18
 of hollow tile, §13, p5
 Shaping of art glass, §42, p41
 Sheathing laths, §38, p5
 Sheet-metal laths, Perforated, §38, p9
 Shell spinning, §42, p66
 Shells, Material for, §42, p67
 Shields, Gas, §42, p58
 Shipping terra cotta, §12, p67
 Shovel, hawk, and hoe, §38, p13
 Shrinkage of terra cotta, §12, p26
 Side-cut brick, §11, p20
 Sill blocks, §13, p14
 tile, §13, p23
 Silo blocks, §13, p24
 Simple mass, Grouping of a, §52, p40
 Single mass, §52, p19
 Size of bricks, §7, p7
 of mortar joints, §7, p9
 Sizes of brick, §11, p15
 of terra-cotta blocks, §12, p13
 Skewback, Meaning of, §7, p47
 Skim coat, of plaster, Troweled stucco, or, §38, p25
 Sleepers, §13, p60
 Slop bricks, §7, p2
 Smoke chamber, §7, p68
 shelf, §7, p68
 Soffit, Meaning of, §7, p48
 Soft brick, §7, p5
 -mud process, §7, p3
 Soldier course, Meaning of, §11, p5
 Solid slabs, §13, p15
 walls, §7, p25
 Solubility, Tests of, §37, p12
 Souring pile, §38, p21
 Span, Meaning of, §7, p47
 Spandrel filling, §7, p48
 Meaning of, §7, p48
 Special tile, §13, p23
 Spinning, Shell, §42, p66
 Spot grounds, §13, p61
 Spotting terra cotta, §12, p33
 Spring line, Meaning of, §7, p47
 Springer, Meaning of, §7, p47
 Square, §38, p16
 Staff, Composition of, §38, p34
 Standards, Bronze, §42, p48
 Cast-metal, §42, p49
 Starting blocks, §13, p19

Stereotomy, §37, p16
 Stiff brackets for gas, §42, p4
 -mud process, §7, p3
 Stock designs of terra cotta, §12, p20
 Stone, base for plastering, Lithic, or,
 §38, p2
 Crushed, §13, p63
 cutting and finishing, §37, p12
 -cutting tools, §37, p12
 Inspection and tests of, §37, p11
 Qualities of good, §37, p5
 Seasoning of, §37, p10
 Table of crushing strength of, §37, p7
 Table of durability of building, §37, p8
 Weight of, §37, p6
 Stones, Color of, §37, p6
 Stonework, Finish of, §37, p16
 Straight electric swing joint, §42, p55
 -hard brick, §7, p5
 edge, §38, p16
 Straightening coat of plaster, §38, p22
 Strength of brickwork, §7, p9
 of hollow tile, §13, p29
 of stones, §37, p6
 of terra cotta, §12, p21
 Stretcher brick, §7, p5
 Meaning of, §11, p4
 or running bond, §7, p40
 Stretchers, §7, p34
 String-course, Meaning of, §11, p5
 -courses, §12, p46
 -courses, Styles of cornices and, §52, p120
 Struck joint, §11, p32
 Structural terra cotta, §12, p1
 Stucco, §38, pp19, 32
 Application of, §13, p64
 Composition of, §13, p62
 finish, §13, p62
 finish, Pebble-dash, §13, p67
 finish, Rough-cast, §13, p67
 finish, Water necessary for, §13, p67
 finishes, §13, p65
 Finishing coat of, §13, p65
 Ingredients of, §13, p62
 or skim coat, of plaster, Troweled, §38,
 p25
 Scratch coat of, §13, p64
 Water for, §13, p63
 Stuff, Character of fine, §38, p19
 Nature of gauged, §38, p19
 Use of coarse, §38, p18
 Subordinate masses, §52, p39
 Sun lights, §42, p58
 Superposition, Definition of, §52, p116
 Supports for floors, Concentrated, §13, p41
 for terra cotta, Steel, §12, p27

Surface designs, §52, p3
 Surfaces of hollow tile, §13, p28
 Suspended scaffolds, §7, p25
 Swing, brackets, Movable, or, §42, p7
 Syenite, §37, p2

T

Table of the Composite order, §52, p76
 of the Corinthian order, §52, p72
 of the Doric order, §52, p60
 of the Ionic order, §52, p67
 of the Tuscan order, §52, p54
 Telephone-conduit tile for foundations,
 §13, p32
 Temples, Cornice and molding, §38, p16
 Terms used in bonding, §7, p34
 Terra cotta, Advantages and uses of,
 §12, p2
 cotta, Anchoring, §12, p69
 cotta, Architect's drawings of, §12, p21
 cotta, Architectural, §12, p1
 cotta, Assorting and stacking, §12, p67
 cotta, Back-jointing, §12, p43
 cotta, Backing up, §12, p68
 -cotta balustrades, §12, p63
 -cotta banded columns, §12, p58
 -cotta blocks, Fitting, §12, p35
 -cotta blocks, Manufacture of, §12, p31
 -cotta blocks, Numbering, §12, p35
 -cotta blocks, Sizes of, §12, p13
 -cotta cartouches, §12, p61
 cotta, Coating or spotting of, §12, p33
 cotta, Coloring, §12, p14
 -cotta columns, §12, p55
 -cotta cornices, §12, p47
 cotta, Design of, §12, p5
 cotta, Designing, §12, p15
 cotta, Details of construction of, §12, p39
 -cotta domes, §12, p64
 -cotta drips, §12, p44
 -cotta drums, §12, p55
 cotta, Economy of, §12, p4
 cotta, Examples of, §12, p78
 -cotta facings for walls, §12, p2
 -cotta finishes and colors, §12, p32
 cotta, Fitting, §12, p68
 -cotta flue linings, §7, p62
 cotta, Full-glazed finish of, §12, p34
 cotta, Glazing of, §12, p33
 cotta, Inspection of, §12, p28
 -cotta joints, §12, p39
 -cotta lintels, §12, p49
 cotta, Manufacture of, §12, p30
 cotta, Manufacturer's drawings of, §12,
 p24
 cotta, Materials used for, §12, p30

- Terra cotta, Mat-glazed or mat-enamelled
 finish of, §12, p34
 -cotta modeling, §12, pp10, 28
 cotta, Molds for, §12, p30
 cotta, Mortar for, §12, p71
 -cotta mullions, §12, p52
 -cotta ornament, Repetition of, §12, p10
 cotta, Packing, §12, p67
 -cotta pilasters, §12, p53
 cotta, Plain surfaces in, §12, p6
 cotta, Polychrome, §12, p4
 cotta, Protecting, §12, p71
 cotta, Qualities of, §12, p3
 cotta, Receiving and checking, §12, p67
 -cotta reglets, §12, p43
 cotta, Setting, §12, p68
 cotta, Shipping and handling, §12, p67
 cotta, Shrinkage of, §12, p26
 cotta, Stock designs of, §12, p20
 cotta, Strength and weight of, §12, p21
 -cotta string-courses, §12, p46
 cotta, Structural, §12, p1
 cotta, Supports and anchors for, §12, p27
 cotta to structure, Securing, §12, p44
 cotta, Vitreous finish of, §12, p34
 cotta, Vitrified, §13, p5
 -cotta wall facings, §12, p45
 cotta, Washing and pointing, §12, p72
 Textile, §13, p26
 Texture, Effect of brick, §11, p21
 in stucco, §13, p66
 of terra cotta, §12, p32
 Thickness and gauge of metals, Table of,
 §42, p66
 of walls, §7, p30
 Three details, Grouping of, §52, p42
 -quarter bat, §7, p34
 masses, Group of, §52, p21
 Throats and dampers, §7, p69
 Ties, Bonding with metal, §7, p43
 for brickwork, Metal, §7, p41
 Tile, §11, p18
 Bonding, §13, p20
 Tiling, §38, p38
 Toggle-bolts, §13, p54
 Toilet fixtures, §42, p32
 Tooled joint, §11, p33
 work, §37, p24
 Tools for raking joints, §11, p35
 Jointing and mitering, §38, p16
 Machine, §37, p15
 Plasterers', §38, p13
 Stone-cutting, §37, p12
 used in bricklaying, §7, p12
 used in finishing joints, §11, p34
 Tooth ax, §37, p13
 -chiseled work, §37, p17
 Trap, §37, p2
 Trim to walls, Attaching, §13, p53
 Trowel, Laying, §38, p13
 Troweled stucco, or skim coat, of plaster,
 §38, p25
 T-shaped hollow tile, §13, p15
 -shaped tile, Walls of, §13, p45
 Tuscan order, §52, p52
 Two details, Grouping of, §52, p41
 -light bracket, §42, p5
 -light combination bracket, §42, p11
 masses, Group of, §52, p19
 Tympanum, Meaning of, §7, p48
- U**
- Unity in architectural composition, §52,
 p13
 Use of moldings, §52, p28
 Uses of hollow tile, §13, p30
- V**
- Varieties and qualities of building stone,
 §37, p1
 Veneered walls, §7, p28; §13, p45
 Veneering on hollow tile, §7, p30
 on hollow tile, Brick, §7, p30
 Vermiculated work, §37, p25
 Vertical lines in the orders, §52, p82
 Vignola's orders, §52, p50
 Vitrified brick, §7, p5
 hollow tile, §13, p5
 terra cotta, §13, p5
 Volute, Ionic, §52, p82
- W**
- Wall construction with hollow tile, §13, p34
 facings of terra cotta, §12, p45
 plasters, Hard, §38, p25
 plugs, Metal, §13, p54
 Walls at angles, Bonding, §7, p43
 Attaching furring to, §13, p53
 Attaching trim to, §13, p53
 Bonding hollow, §7, p42
 Brick, §7, p25
 Curtain, §7, p28
 Damp-proofing brick, §7, p26
 Double, §7, p26
 Enclosure, §7, p27
 Examination of, before application of
 plaster, §38, p20
 Finishing gable, §13, p45
 Fire, §7, p27
 for plastering, Preparation of, §38, p2
 Hollow, §7, p26
 H-tile, §13, p44
 Joining new walls to old, §7, p45

Walls of brick, Interior, §11, p55
 Openings in, §7, p45; §13, p49
 Panel, §7, p27
 Party, §7, p27
 Solid, §7, p25
 Terra-cotta facings for, §12, p2
 Thickness of, §7, p30
 T-shaped tile, §13, p45
 Veneered, §7, p28; §13, p45
 Warehouses, Hollow-tile, §13, p75
 Wash drawings, §52, p143
 Washing terra cotta, §12, p72
 Water for stucco, §13, p63
 for stucco finish, §13, p67
 -struck bricks, §7, p2
 Weathered joint, §11, p33

Weight of bricks, §7, p7
 of stone, §37, p6
 of terra cotta, §12, p21
 Well-burned brick, §7, p5
 White coat of plaster, Hard-finish, §38, p25
 Whitewashing, §38, p35
 Windsor-cement plaster, §38, p26
 Wire-cut brick, §11, p19
 laths, Stiffened, §38, p7
 Wires, Space for, §42, p30
 Withes, §7, p61
 Wood bricks, §7, p60
 construction, Metal laths in, §38, p9
 Wooden ceiling lights, Carved, §42, p44
 laths, §38, p3

